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DESIGN PRODUCTION PROCUREMENT

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Parts per year (Req'd. Prod.)	10,000	10,000
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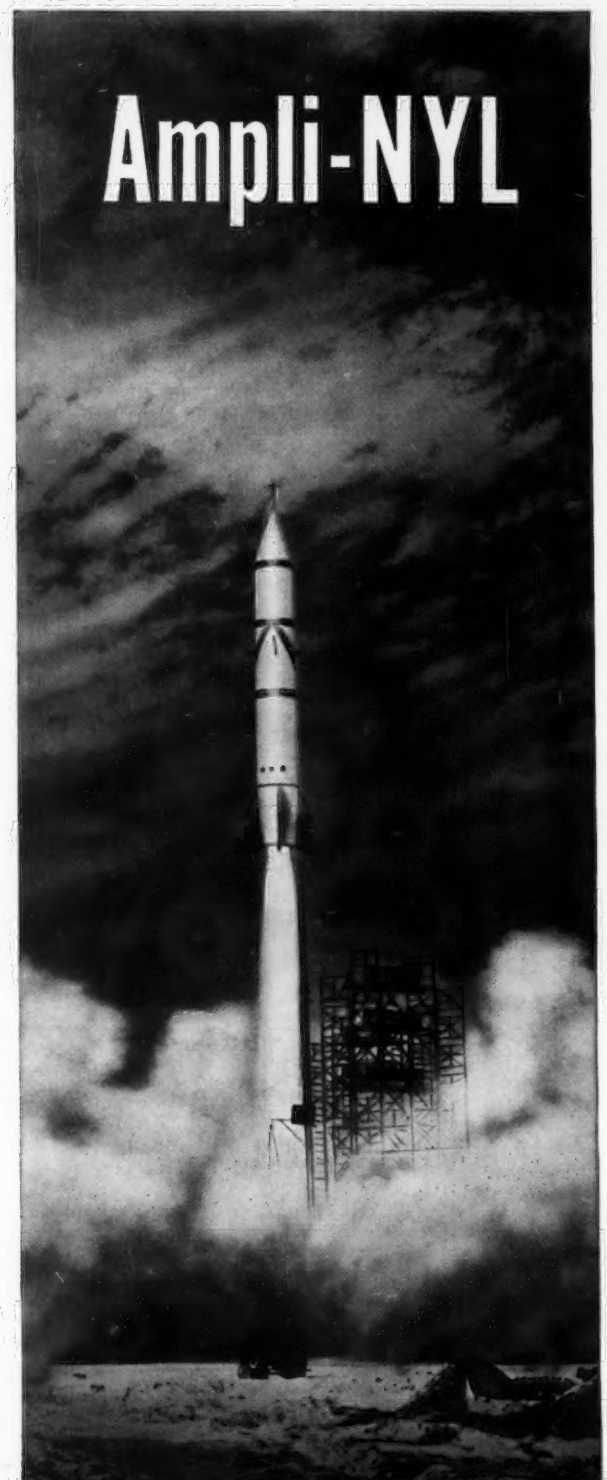

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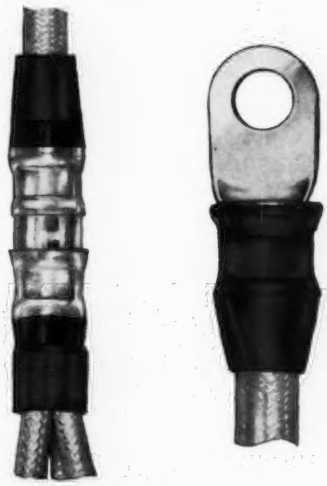

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JULY 1958

VOLUME 1, NUMBER 7

DESIGN
PRODUCTION
PROCUREMENT

A CHILTON PUBLICATION

THE COVER STORY

The principle of autorotation utilized by rotary-wing aircraft has probably been in operation since the early appearance of plant life on this planet. To compensate for the static mode of existence of plants, seed propagation has been insured through the evolution of plane fruit. A good illustration of this phenomenon is to be found in the aerodynamic characteristics of the single samara of the ash or elm, or the double samara of the maple, capable of riding the winds.

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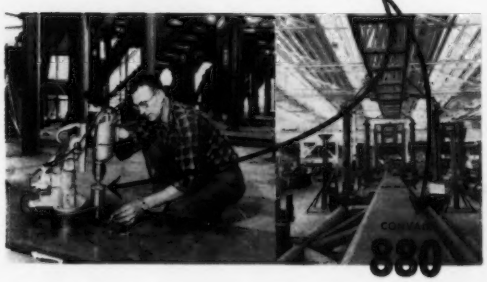

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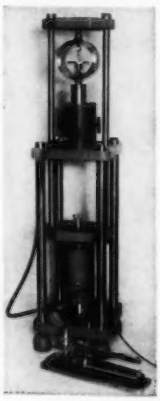

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What is reliability?

Seems like almost everyone today is talking about the reliability of products. How many people really know however, what reliability really means? Webster says, "to rely on implies a judgment based upon experience or association." Actually, reliability is how much we trust something.

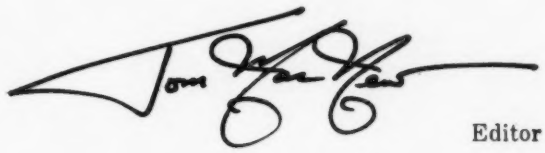
In recent months there has been a great deal of criticism concerning the reliability of certain missiles. For some reason, people tend to believe that reliability was born of the missile age. This just isn't so.

Let's stop and think of just how reliable our new and expensive automobiles are, and after all, the car manufacturers have been making cars for years and years.

A recent booklet, put out by Standard Pressed Steel, calls to mind that reliability is born of variability. If all factors were known, the products would either be worthless or completely trustworthy. With reliability of course, we have two major unknowns—the environment and the products' ability to withstand that environment. An Atlas missile is said to contain some 300,000 parts. If this missile were made to hit the target nine out of every ten firings, then each of the parts must have a reliability rate of 99.99996 per cent. It may sound utterly fantastic, but this is what we are striving for. This is what we must have.

When we send a man into space, we will want him to return safely. Without doubt, our reliability percentage should be even higher than the case just mentioned.

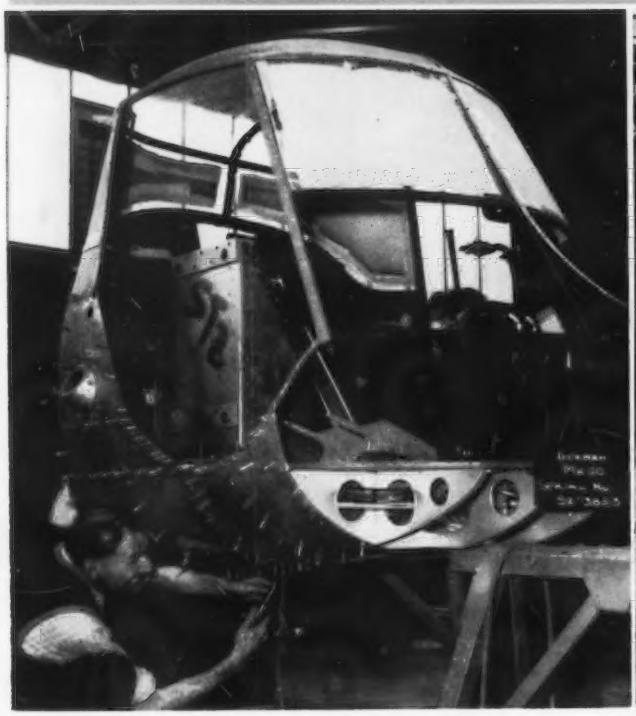
Perhaps it will not be too long before requests will be made of manufacturers for complete assurance that parts will not fail. Or, if they do, they will fail-safe.



Editor

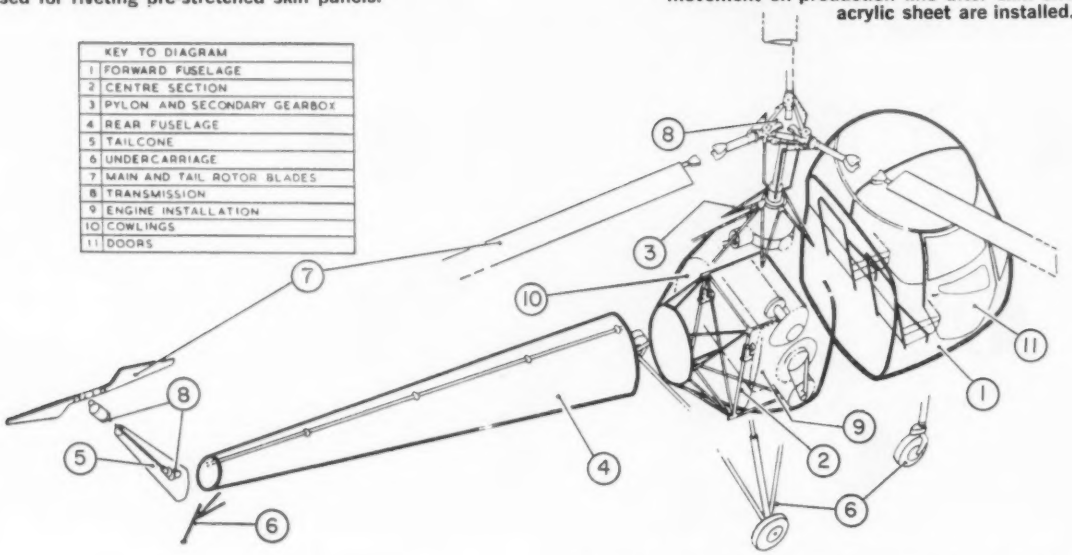
Skeeter copter in production

dozen sub-assemblies facilitate final integration and keep cost down



Jig used for assembling the forward fuselage section is dual purpose. Shown here it is a stationary fixture used for riveting pre-stretched skin panels.

The assembly jig can be fitted with a detachable nose wheel to make it completely mobile for movement on production line after skin and acrylic sheet are installed.



It was not until Saunders-Roe received a quantity order for the Skeeter that full advantage could be taken of this light helicopter's natural "break joints."

The production breakdown comprises the following major assemblies: forward fuselage, center section, pylon, engine, undercarriage, rear fuselage, tail cone, rotor blades, transmission, doors and cowling panels. All are built to a programmed output so that they are ready for assembly when needed. Special care is taken to ensure interchangeability of parts. This facilitates final assembly and the fitting of spares in the field.

Fuselage Construction

Stage-by-stage production is evident first in building the forward fuselage. Two jigs are used. The structure, less canopy, is assembled in the first. The second jig is used for assembling the canopy structure, fitting the acrylic sheet top and side panels, installing the flying controls, hydraulics and electrics, and riveting the pre-stretched skin panels, which are trimmed to shape on assembly.

To keep their weight low, the door frames of the cabin are made from light square-section alloy tube and are extremely pliable. Addition of the acrylic sheet and skin panels stiffens the whole structure considerably. The jig used is designed to incorporate a detachable wheeled frame, and becomes completely mobile once a nose-wheel has been fitted to the forward fuselage.

The center section and pylon, which are of welded steel-tube construction are first built up as small units in sub-assembly jigs and then brought together for final assembly in the main jigs. Investment castings are used at the center-section corners for joining the tubes. This greatly facilitates welding, offers a saving of man hours, and produces a cleaner-looking weld.

To prevent excessive distortion and difficulty in removing the finished component from the jig, all joints are welded in sequence, and each completed joint is allowed to cool before the next is welded. In addition, spring-loaded locations are incorporated in the sub-assembly jigs to allow for shrinkage after welding. On completion, the center section is checked for interchangeability by the acceptance gage, the requirement being to match pick-ups on the forward fuselage, the rear fuselage, the pylon and the engine.

The rear fuselage and tail cone are of light alloy monocque construction and are covered with pre-stretched skin plating.

Rotor Blade Production

Rotor blade production is an exacting science, as the behavior of the Skeeter depends to a large extent on the standard of the blades produced. Basically, each blade is made of a tubular steel spar, on which ply veneers are Redux-bonded at intervals. To these veneers are glued the secondary wooden structure of ribs and leading and trailing edges, after which the whole assembly is dressed to contour and doped. At this stage a ply skin, scarfed at intervals, is glued on

continued on next page

Section of Skeeter line showing monocoque rear fuselage section and fabricating jigs.

Skeeter copter

continued

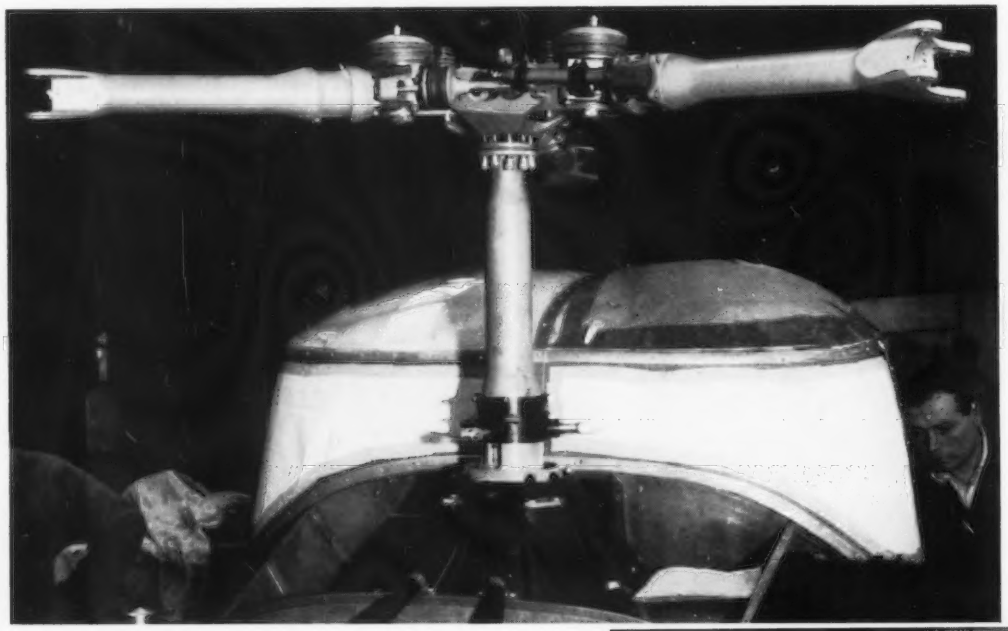
the leading edge; and a metal trailing edge, coated on the inside with Araldite, is fitted.

The assembly is checked for straightness and the leading edge weights are fitted but not glued. Following a C.G. check and static balance, the weights are glued with Aerodux. Next, Madapolam and fabric covers are cut and doped in position; the leading edge capping is fixed and checked, then doped and inspected. Finally, the root-end fitting is drilled and pinned, and the last doping operation completes the blade for final clearance. This involved checking the C.G. again and static and dynamic balance.

Rotor Drive

The drive of the main rotor blades is through a primary gearbox located on the starboard side of the engine crankshaft and a secondary gearbox mounted on the fuselage center section. The secondary gearbox supports the main rotor shaft. A centrifugal clutch is incorporated in the primary gearbox. The centrifugal clutch can be overridden by a manual control, to enable the engine to be run up independently of the rotor. The tail rotor is driven from the secondary gearbox through shafting to an angle gearbox and a tail gearbox.

Each group of gearbox units is inspected



Main rotor is simple in design. The main rotor shaft is a "tube forging." Shaft is supported by the secondary gear box.

Airframe receives the main undercarriage in final assembly and is moved down production line free of jigs or fixtures, to receive engine flight, controls and electrical equipment.

for flaws and for wear after a three-hour run on a "running-in" rig, so that it can be cleared for assembly on the Skeeter without interruption of the flight program.

All details making up the transmission system are routed through the shops on a full contract batch basis, except for certain gears supplied by specialist firms.

Forgings are used whenever possible, to cut machining time, typical examples being the main rotor shaft and cooling fan blades. Originally the main shaft was bought as a solid forging, but subsequently "tube forging" was introduced. This has resulted in a 50 per cent saving in machine time for the main rotor shaft. Use of forgings instead of castings for the cooling fans has led to a saving of 87 per cent in machine time.

Use of Adhesives, Glass Fiber

Production of the transmission items is speeded by the use of adhesives. A case in point concerns the tail rotor drive shafting, which consists of one in. diam tube with splined ends and intermediate journal bearings, using Araldite resin compound as the adhesive. These are torque-tested to 230 ft-lb before being completed by the addition of taper pins.

A further example of the use of adhesive as a production aid is in the manufacture of the torsion bars situated in the main rotor head. These consist of four lengths of steel, since one as a solid bar would require an excess force to make the unit operative. Each bar requires a ground thread at either end which must be machined and ground as a complete unit. Therefore, these four lengths have their respective mating faces ground at right angles, forming a perfect nest at the center, and are bonded together with an adhesive compound similar to that used for the tail-drive shafting. This adhesive is not fully cured, and so the four pieces can be separated easily on completion of the machining operations.

The cowling panels which are formed of glass fiber to ensure rigidity and light weight, are inspected in a gage which consists of a dummy center section complete with removable master metal panels. The procedure is simply to replace each master panel in turn with a production panel. The profile is checked by using a slip gage against the surrounding master panels and/or either firewall. By this method interchangeability is achieved since any panel is assured of nesting snugly on assembly to any Skeeter.

This completes the "production breakdown" of the main assemblies required to complete the aircraft prior to wheeling it from the assembly shop.

Final Assembly

The next operation is to remove the wheeled frame from the forward fuselage and bolt the center section complete with the pylon to the forward firewall. The main undercarriage is then attached and the aircraft is ready to receive the rear fuselage. This is bolted to the rear firewall.

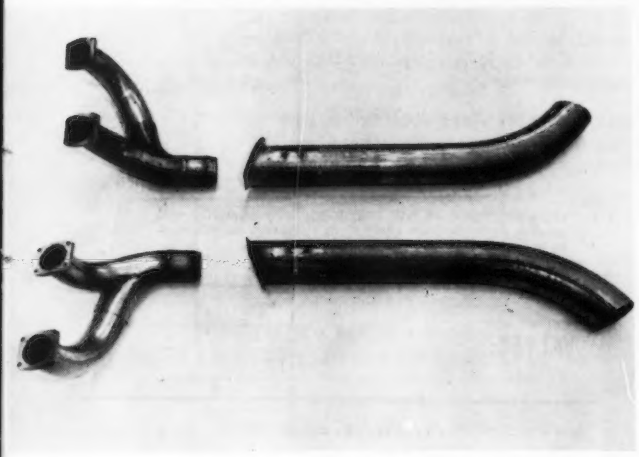
The engine is then mounted transversely into the center section and is lifted and slid into position. At the same time, the secondary gearbox and drive shaft are assembled to the pylon, which is then placed as a complete unit on the center section. Fitting of the tail cone, complete with the two gearboxes and shafting, allows the two-bladed tail rotor to be assembled.

Meanwhile the installation of the cable-and-rod type flying controls, together with pitch stick and bias trim, is underway. This, in conjunction with assembly of the main rotor hub and primary gearbox, allows the main rotor blades to be fixed. It only remains to complete the installation of the seats for pilot and observer, control covers, instruments, radio, cabin and access doors and the general tidying of the systems, before fitting the cowling panels with Dzus fasteners.

After an inspection clearance, the Skeeter is then ready for final painting, and then—flight trials.

◆

Saunders-Roe fabricates single seam welded exhaust system for the deHaviland Gipsy Major 215 powerplant. Welded stacks are filled with Cerrobend and formed on a hydraulic pipe bending machine.



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spin-forming the Talos diffuser

Hydro-Spin technique integrates composite structure of cone.

by Joseph Geschelin

Because the design and manufacture of rockets and missiles is a new and accelerating art, radical breakthroughs in manufacturing techniques are a must if real progress is to be achieved. Judging by recent developments one sure source of such accomplishment is the specialist in component production—the sub-contractor.

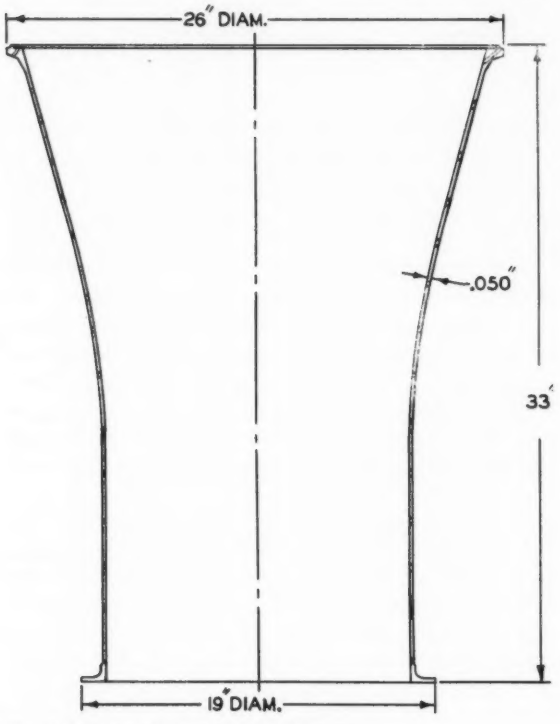

Fig. 1 Cross-section of Talos diffuser.

To cite a specific example, we refer to the contribution of the Ingersoll-Kalamazoo Div., Borg-Warner Corp. In one of its most productive areas, this company is conducting research and development projects stemming from their background of experience with the Cincinnati Hydro-Spin technique. The case in point is a project leading to the fabrication of a diffuser for the Talos missile. Formerly, the diffuser was made of rolled and stretched aluminum sections joined by hundreds of rivets.

The problem was how to make the component not only at less cost but more rapidly. Better quality control and improved physical properties were also desired. All of these requirements have been met by the Hydro-Spin technique.

It required creative thinking and a lot of know-how to come up with a process that could be readily translated into a mass production method. The sketch of the diffuser, Fig. 1, shows the general configuration in cross-section with some nominal dimensions. It is made of non-critical warehouse plate steel of C1010 spun to a uniform wall thickness of 0.050 in.

To produce this multiple-contour component, it was necessary to sub-divide it into two major sections and two end flanges, Fig. 2. The bell-end conical section is made separately to a

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spin-forming the Talos diffuser

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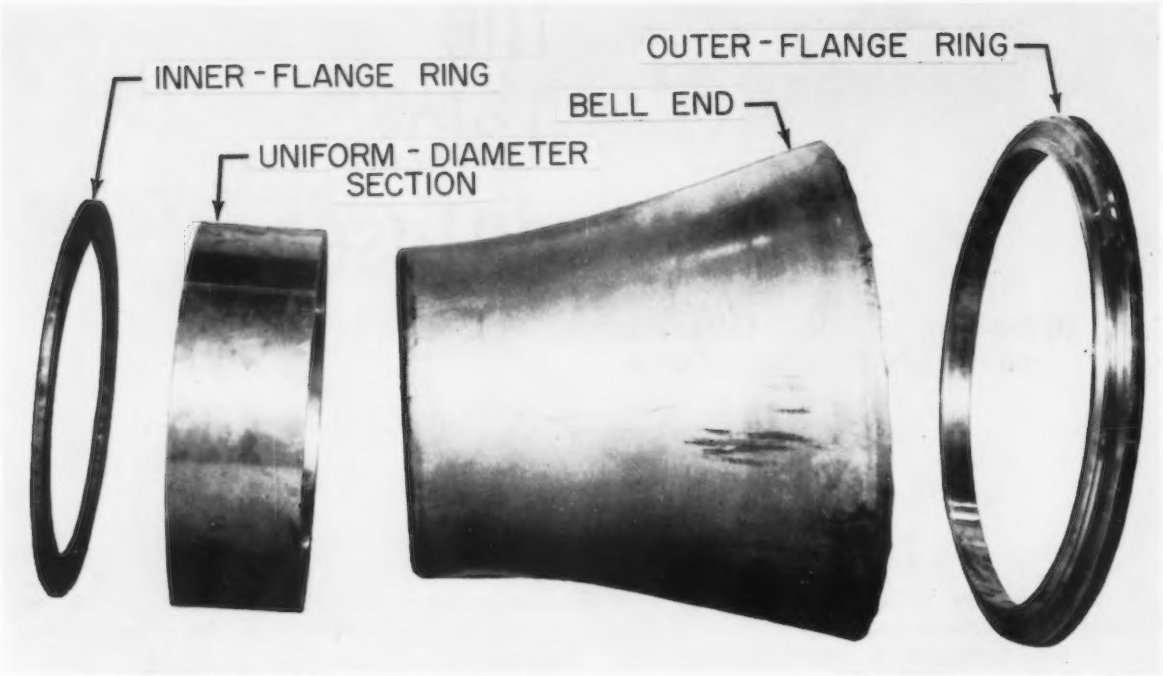
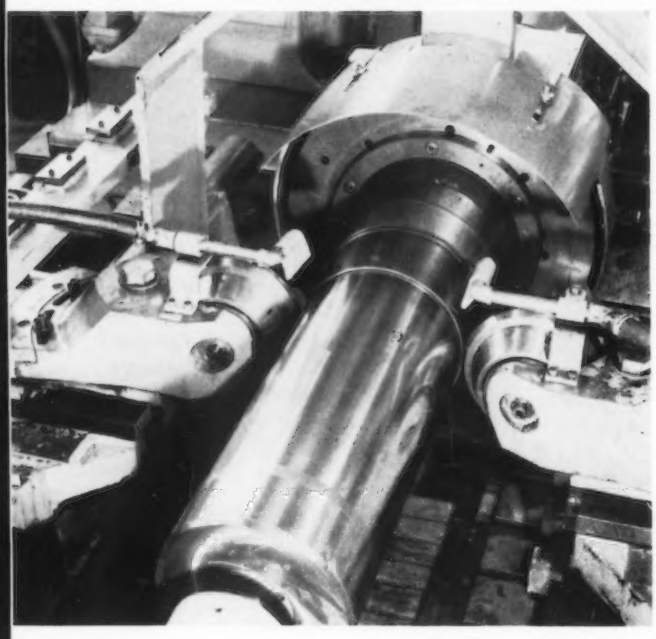


Fig. 2 Basic elements of diffuser.

Fig. 3 Close-up of Cincinnati Hydro-Spin machine with mandrel and tooling set to spin constant-diameter section.



specific preform shape and thickness, by spinning it over mandrels, starting with a rough-cut disk of mild-steel plate. This requires three individual preform operations, using a series of three different mandrels.

The small diameter is trimmed square and the preformed bell-end is ready for welding.

Meanwhile, the constant-diameter section of the diffuser is prepared by spinning a tube of controlled wall thickness, then cutting it into sections of suitable length as seen in Fig. 2. For this purpose, a short section of purchased thick-walled tubing is drawn into a long tube with a thin wall, Fig. 3.

Now that the two major sections of the diffuser have been prepared, the tube bell-end, and flange of the smaller end are assembled by automatic submerged-arc welding. One of the secrets of the success is that wall thickness as well as diameters can be held to close tolerances, thus making it a relatively simple matter to match up the sections for welding without machining.

Fig. 4 Hydro-Spin machine fitted with final form mandrel.

After a stress relieving operation, the diffuser is ready for the final Hydro-Spin. This involves accurate contouring as well as extrusion to the developed length. A single form mandrel, Fig. 4, is used.

Upon completion of final spinning, the large end is trimmed at the required diameter. The end flange is then welded in place. A lip of greater thickness was previously spun on the bell-end to provide greater strength at the weld joint. The lip compensates for the annealing effect produced by welding.

Each weld is thoroughly X-ray inspected. Also, the part is subjected to a Magnaflux Magnaglo inspection to assure freedom from surface or sub-surface defects that initiate stress failure.

While per-unit cost and productivity are controlling factors, the process also yields some important plus values. For example, since mild steel is used, the process is self-checking as imperfections in the blanks are revealed early in the production sequence. Attendant heavy pressures will crack any blank with inclusions or sub-surface seams and cracks. Also, in spin forming, the heavy pressures required to produce plastic flow refine the grain structure and effect an orientation of grain parallel to the principal axis, in much the

continued on next page

spin-forming the Talos diffuser

continued

After final spinning, diffuser leaves machine as seen at left; diffuser at right has been trimmed to accommodate flange ring.

same manner as forging. Cold-working of the metal also increases tensile properties appreciably. Experimental results indicate that mild steel with a yield strength of 33,000 psi will be improved to 60,000 psi.

Another characteristic of the process is that plastic flow, incident to the extrusion of the section, completely erases the circumferential weld. The effect appears to coalesce the welded seam into the general pattern of the grain structure so effectively as to mask its identity completely. ✦

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The Editor
AIRCRAFT and MISSILES MANUFACTURING
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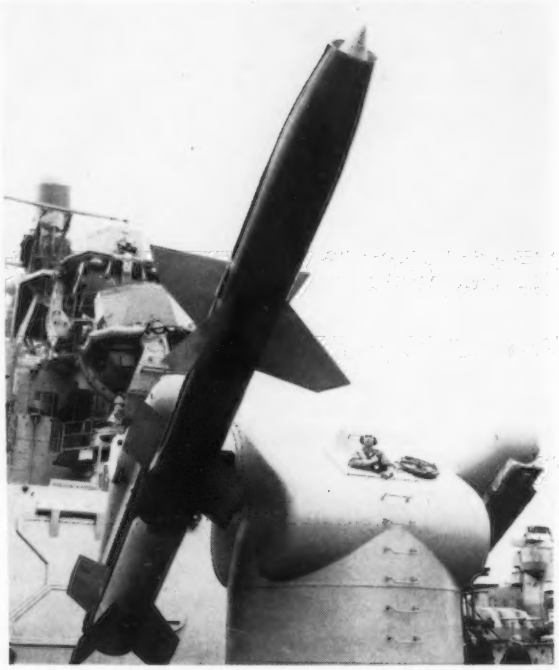


Talos supersonic guided missile is standard equipment on new USS Galveston. Prime contractor of the 3000-lb ramjet missile is Bendix Aviation Corp. Talos has 65 mile range and operates at stratospheric altitudes.

Circle 59 On Inquiry Card, page 65 ⟶

HOW TO SAVE TIME AND MONEY IN MISSILE METALWORKING:

Employ a Cincinnati Hydroform-Hydrospin *team!*

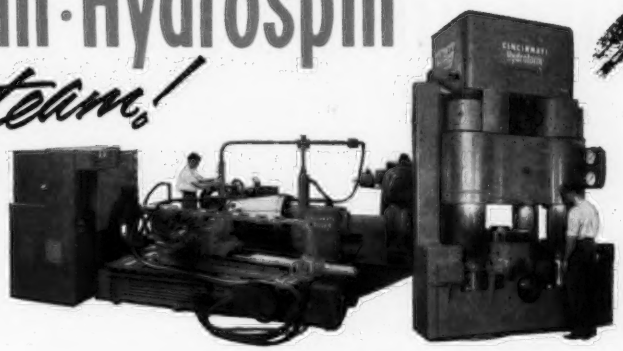


Fig. 3

Fig. 2

Fig. 1

Shown at left are three quick steps of producing a guided missile component employing a Cincinnati Hydroform-Hydrospin winning team.

Using low-cost tooling, the preform (Fig. 1) was produced in one draw, without thinout, from a 23″ diam. blank of 6061 Aluminum on a Cincinnati 32″ Hydroform. Size of preform is 12″ major diam. x 13″ deep x ⅛″ wall thickness.

After heat treating, the preform was "*chipless machined*" on a Cincinnati Hydrospin. The first spinning (Fig. 2) roll-flowed the preform to 20″ length x 12″ major diam. x 0.080″ wall thickness. Floor-to-floor time; 3½ minutes. The final spinning (Fig. 3) increased part length to 40″ and reduced wall thickness to 0.040″ ± 0.005″. Floor-to-floor time; 4¼ minutes. The alloy of the finished part is in the T6 condition.

You'll save costs and speed missile parts production with Cincinnati® Hydroform® and Hydrospin® machines. Call in a Meta-Dynamics Division field engineer for full details.

Hydroform/Hydrospin

META-DYNAMICS DIVISION

Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

ceramic radomes for missiles

alumina (Al_2O_3) slurry sprayed on mandrel, pressed to shape, and baked at 3000° F

Pre-form mandrel is machined from steel and chromium-plated. Shrinkage in the final shape is allowed for in the mandrel design.

The mandrel is mounted on an electrically powered turntable, and sprayed with a slurry of Al_2O_3 and an organic binder. The binder volatilizes in subsequent heating operations.

Masking materials are removed prior to readying the sprayed mandrel for application of heat and pressure.

A neoprene bag is placed over the entire assembly. Gladding, McBean, Los Angeles, Calif., uses this method of radome construction.

The bagged mandrel is lowered into a pressure vessel where a uniform force of 30,000 psi is applied. After this cold press, the nose cone has sufficient strength to be removed from the mandrel.

The nose cone is given an initial firing at 2200° F and machined to final configuration. Final firing is at 3000° F.

The ceramic-coating art, developed over the past decade as solution to heating and erosion problem, has advanced to its ultimate goal: the all-ceramic missile nose cone. This development offers missile manufacturers new design freedom in their attack on high-speed nose cone problems.

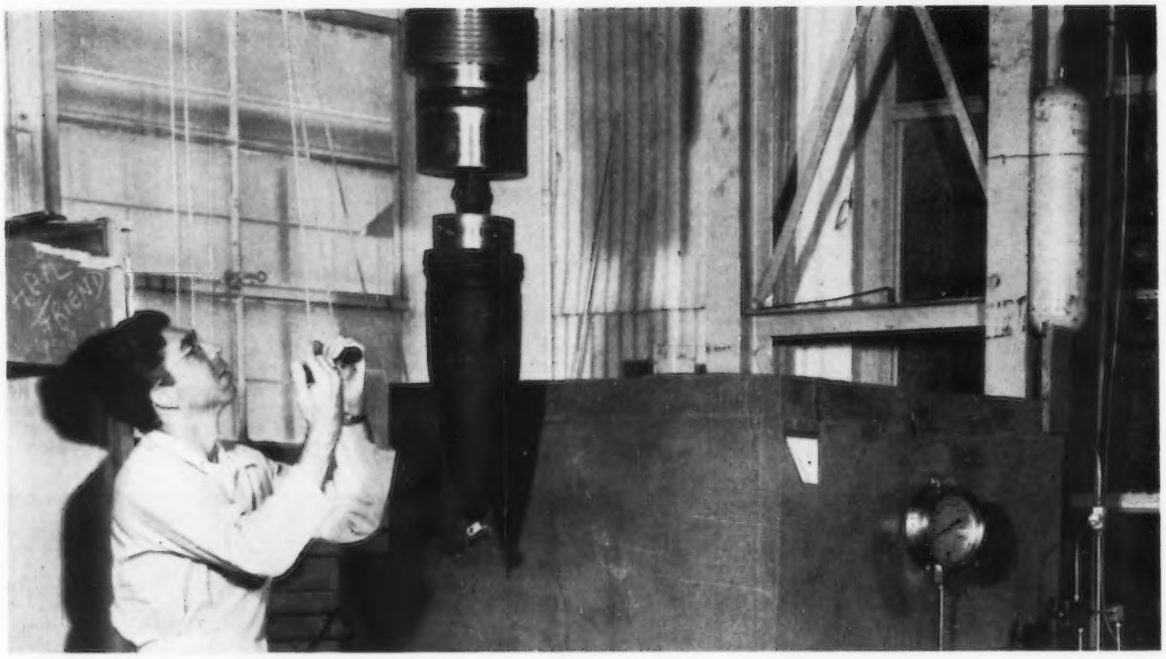
Important feature of the development is the attainment of required uniformity of radar wave transmission by holding the wall-thickness tolerance to $\pm$ 0.001 in.

First step in the development program was selection of a ceramic material capable of meeting severe physical and electrical properties requirments. High-purity alumina (Al_2O_3), one of the strongest ceramic materials was selected. Next step was development of techniques and equipment practical for molding, pressing, machining and firing the radome. Past methods of pressing, extruding, slip-casting or "jiggering" proved incapable of meeting requirements for shrinkage, or electrical uniformity.

The problem was solved by development of a technique involving spraying and hydrostatic pressing. First step in the new fabricating technique is preparation of a pre-form mandrel, accurately machined from steel and chrome-plated to a high finish. This form is created by working backward from the outside curve and must include the anticipated shrinkage of the ceramic coating in the process. *continued on next page*

ceramic radomes for missiles

continued



Evacuated radome unit prior to introduction into pressure vessel.

The form is sprayed with the ceramic material. Spraying should be high enough to provide packing of Al_2O_3 particles.

Formulation of the spray material meant creation of a ceramic slurry that would possess an initial viscosity low enough to pass through the spray gun, dry rapidly to produce hardening between passes of the gun, and possess an adhesive quality necessary to make it stick to the polished mandrel. The solution developed is composed of 97 percent alumina, the balance being an organic resin soluble in a volatile liquid. It is "tacky" upon build-up, and does not run down the surface. The organic resin is removed during the preliminary firing by the action of the heat.

The mandrel is mounted on a powered turntable. The table is rolled into a spray booth and set in motion. The operator sprays the rotating mandrel from tip to base repeatedly until a wall of sufficient thickness (determined by a template) has been built up. Individual operator skill is a vital ingredient, since the proper balance between liquid surface pressure and atomizing air is essential for satisfactory deposition of the material. The radome shape is allowed to dry at room temperature, after which it is ready for pressing.

The entire assembly is placed in a neoprene bag and lowered into a pressure vessel, where it is subjected to a pressure of 30,000 psi. This pressure, uniform over the entire surface, produces an exceedingly low and uniform shrinkage rendering a final diamond grinding unnecessary. After this pressing, the radome has sufficient strength to permit its removal from the mandrel. It is then given a preliminary firing at 2,200°F. This bisque (or biscuit) treatment produces sufficient strength in the piece to permit machining to final wall thickness and configuration. A minute allowance for the shrinkage during final firing must be considered.

The final firing is at a temperature of more than 3,000°F. in a regenerative-type kiln. This produces the ultimate strength of the part and results in a strong radome meeting electrical, thermal and dimensional requirements for guided missile use. ✦

When the END RESULT must be FULL RELIABILITY

MAGNAFLUX TEST SYSTEMS

supply the MEANS

In today's missiles and aircraft, so much depends upon so little! As aircraft and missile men know, failure of just *one* of the many components linked together in complex systems, can put the whole system "out of business." *Every part* has become a critical part!

In this equipment chain, parts of *normally* high reliability can be intolerably *unreliable* as part of the whole interdependent system. When one failure in 1000 is too many — and may cost a million or more dollars — only reliability standards approaching the fantastic are good enough.

Similarly, only scientific inspection and testing systems can hope to maintain such standards.

Magnaflux Nondestructive Testing Systems provide the means. Proven practical and economical in just such uses, they enable you to assure the physical reliability of components — whether precious one-of-a-kind units or volume production items. These Test Systems are so precise in their findings that, in their recommended service, *not a crack, leak, or defect* that you need to find will go undetected. They cover the whole range of magnetic or nonmagnetic metals, ceramics or other materials you work with, design for, or fabricate. Also, eddy current Magnatest equipment controls metallurgy, heat treat, hardness, etc. — in further nondestructive tests.

These Magnaflux Test Systems are currently helping to assure near-infallability of materials for producers of components used in many missiles and aircraft. They are providing testing standards *to fit the need* . . . helping to keep both testing and production schedules *on schedule* . . . and saving a great deal of money for prime and subcontractors besides! Note, too, you don't need to buy test equipment. We have service testing facilities in 16 cities.

To find out what Magnaflux Test Systems can do for *you* write for a meeting and idea session with an experienced Magnaflux Engineer. You set the time and place. There's no obligation, of course — but plenty of help for the asking.

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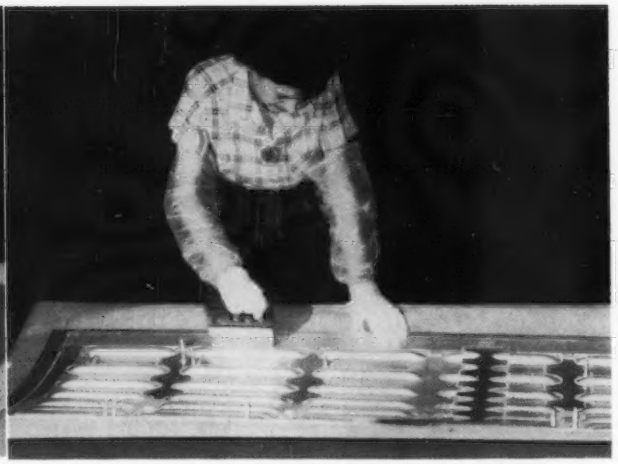
The Hallmark of *Quality* in nondestructive test systems

Circle 60 on Inquiry Card, page 65

Hustler . . . 95 per cent adhesively bonded

Application of the two part adhesive system to the outer skin of the fuselage. This will be mated with a beaded inner skin.



Doublers are tack bonded to the inner skin of the beaded fuselage panel prior to final bonding in fixture.

So revolutionary were the concepts in airframe development of the Hustler, that they represented a departure as radical as the replacement of wood and fabric by the all metal monocoque structure.

In the past decade Convair made use of metal to metal adhesive bonding on some secondary structural components of the B-36. With the advent of the B-58, adhesives were used not only in secondary structural applications, but in primary components. Adhesives were adopted so widely in the airframe that 95 percent of the aircraft surface is bonded structure.

With this in mind there are several reasons why the Hustler makes an excellent example to represent the achievements and growth possibilities of adhesives in the aircraft and missile industry.

- Aircraft performance is such that sustained high stresses and severe temperature conditions are induced.
- The vehicle is one of the first manned aircraft to use adhesives in primary structures.
- Bonded components are being made with production proven processes.

Why Bonded Structure?

In the preliminary design phase, twelve different designs for skin coverings were evaluated. Designs ranged from conventional riveted-sheet-stringer construction, to corrugated-doubler construction spot-welded to the skin. Only the bonded structures presented all of the following desired properties:

- Aerodynamic smoothness at high stress levels and elevated temperatures.
- High structural efficiency in the expected operating environments.
- Simplicity of design and resultant lower cost.
- Excellent fuel sealing for integral tank construction.

where, how, and why bonded structure is used on our hottest production bomber

by **W. K. Bailey,** wing design engineer,
R. A. Fuhrer, chief manufacturing engineer,
Convair-Fort Worth, a division
of General Dynamics Corp.

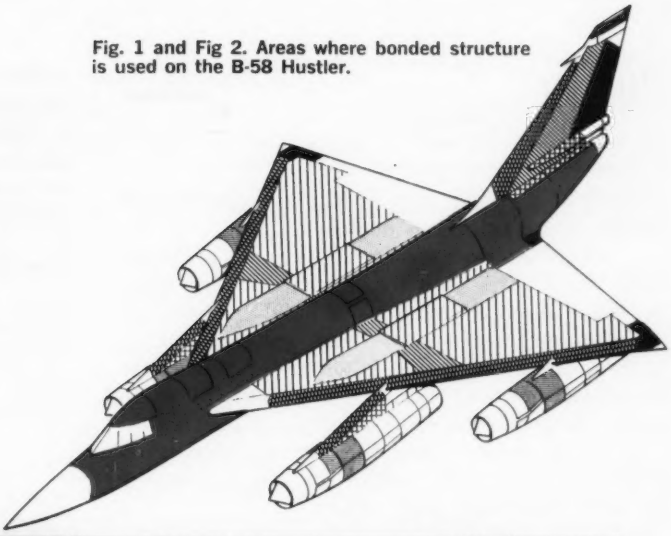
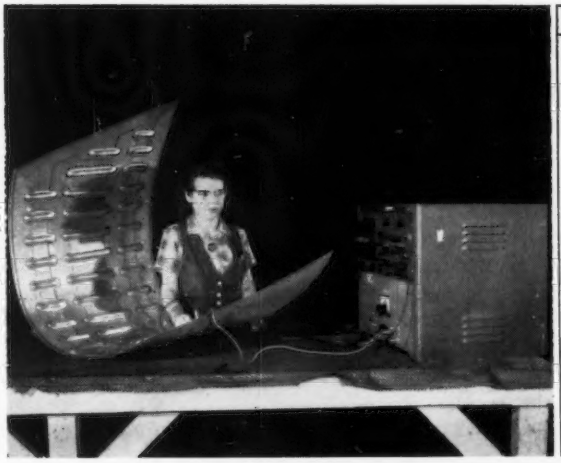


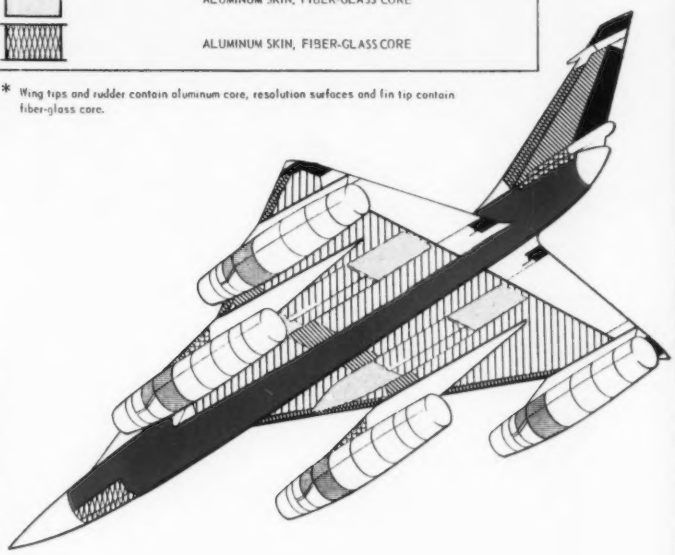
Fig. 1 and Fig 2. Areas where bonded structure is used on the B-58 Hustler.



Bonded fuselage panels (beaded construction) are tested ultrasonically with a Stub meter to evaluate the bond.

CORE	MATERIAL
	ALUMINUM SKIN, BEADED PANELS
	ALUMINUM SKIN, FIBER-GLASS CORE
	ALUMINUM SKIN, ALUMINUM CORE
	ALUMINUM SKIN, ALUMINUM CORE
	ALUMINUM SKIN, FULL DEPTH CORE *
	ALUMINUM SKIN, ALUMINUM CORE
	ALUMINUM SKIN, ALUMINUM CORE
	ALUMINUM SKIN, FIBER-GLASS CORE
	ALUMINUM SKIN, FIBER-GLASS CORE

* Wing tips and rudder contain aluminum core, resolution surfaces and fin tip contain fiber-glass core.



- Insulation of fuel from aerodynamic skin heat.

Where Bonded Structure Is Used

Figure 1 is a schematic of the upper surface of the aircraft with the shaded areas showing where honeycomb bonded structure is used. Figure 2 shows the lower surface. From these drawings it is apparent that bonded structure is used over practically the entire wing and tail surfaces, and that it is used extensively in the pylon and nacelle structures. The fuselage also uses bonded structure. However, this is not honeycomb. It is an integral beaded type panel. The elevons (unshaded portion on aft of wing) use brazed stainless steel honeycomb sandwich, as do portions of the engine nacelles. (AMM, March, 1958, "Brazing Hustler's Stainless Sandwich.")

For simplicity, all bonded structures can be considered as falling into two general types: the beaded panels, used in the fuselage; and the sandwich panels, used in varying forms in other areas.

The complete fuselage is a simplified monocoque type, with metal-to-metal bonded skins. The interior fuselage structure is a series of machined and build-up bulkheads. A beaded panel

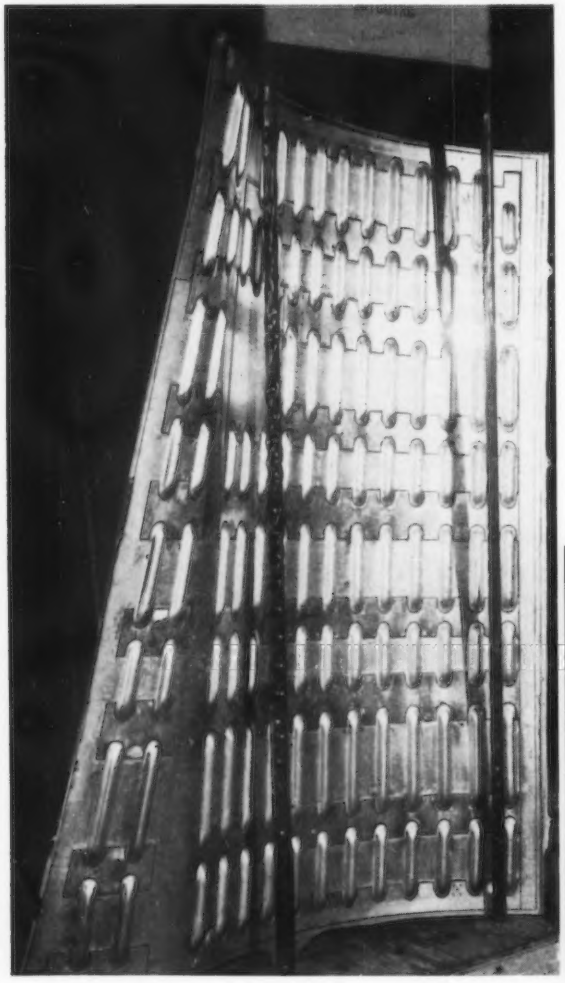
continued on next page

consists of an outer skin, a drop-hammer-formed beaded inner skin, and doublers.

The interior structure wing is of three basic types. One is a machined boundary spar, the other two are variations of build-up members forming span-wise spars. There are eight major build-up bulkheads and a series of span-wise spars, all identical with the exception of their particular geometry. This structure is covered by a series of panels called the integral slug type, which, again, are identical in construction except for their particular geometry.

The vertical fin is made up of the same structure as the main wing box section. All access doors of the fuselage are the same construction as the fuselage itself. Landing gear doors of non-integral slug-type design are also standardized in construction. Wing and fin leading edges are of the non-integral slug-type design, and are of the same standardized construction as many other portions of the aircraft.

Completed fuselage panel shows that reverse curvatures are possible.



How Bonded Structures Are Made

All of the bonded panels follow the same production flow:

- Fabrication of details.
- Prefitting of parts into assemblies.
- Cleaning of parts.
- Lay-up of parts with adhesive applied into assemblies.
- Bonding of assemblies in either an autoclave or a bonding press.

One of the most important factors in determining the ultimate usability of a bonded component is its aerodynamic cleanness of fit. Therefore, great emphasis is placed on prefitting detail parts into assemblies prior to the cleaning and bonding cycle. Tolerances average about 0.005 in. during the machining operation of detail fabrication.

Once the parts go into the cleaning line they are not touched by bare hands until the bonding operation is complete. All workers who handle the parts wear clean, white, cotton gloves. Human and vegetable oils readily contaminate the metal and adhesive, reducing the strength of the bond.

The cleaning cycle consists of hand wiping with methylethyl ketone (MEK), and vapor degreasing in stabilized trichloroethylene until vapor ceases to condense on the parts. The next step is an 11 min dip in an acid solution of the following composition:

sulfuric acid .....10 parts by weight
sodium dichromate .. 4 parts by weight

Special holding fixtures and bandsaw are used for slicing honeycomb billets. Bonded honeycomb panels are used in wing, nacelle, and tail sections

ADHESIVES USED IN HUSTLER BONDING

Adhesive	Type	Manufacturer	Areas Used
Narmco 4021	nitrile-rubber-phenolic	Narmco Resins and Coatings Co.	Fuel cell sealing, honeycomb panel (metal-to-metal)
Plastilock 620	nitrile-rubber-phenolic	B. F. Goodrich Co.	Fuel cell sealing, honeycomb panel (metal-to-metal)
Aerobond 422	epoxy-phenolic	Aerobond Co.	Beaded panels, honeycomb panels (core-to-metal)
Shell 422-J	epoxy-phenolic	Shell Development Co.	Beaded panels, honeycomb panels (core-to-metal)

water .....30 parts by weight

This is followed by a 3 min rinse in tap water below 160°F, a 5 min spray rinse with de-ionized water, and a final rinse with distilled water and filtered compressed air. After force drying at 150°F for 10 min, the parts are ready to receive the adhesive.

A dual adhesive system is used on some parts (combination of liquid primer and unsupported tape). Other parts use only a supported tape adhesive. Honeycomb-core to skin areas are bonded with Aerobond 422 or Shell 422-J, of 0.010, 0.015, and 0.020 in. thicknesses. Metal-to-metal areas are bonded with Plastilock 620 or Narmco 4021 adhesive systems, nominally 0.009 in. thick. Both of the latter adhesives use a liquid primer and an unsupported tape.

In the application of the metal-to-metal adhesive, the cleaned, primed parts are heated slightly to insure that the tape adhesive sticks to the parts. The core-to-metal adhesives are supported by a glass fabric carrier and are in themselves "tacky" enough to adhere to the parts during layup. The supported tapes are applied directly to the cleaned metal surface at room temperature without using a primer liquid.

Bonding Fixtures

After the adhesive is applied, parts are laid-up in assemblies and bonded in one of two ways: bonding presses with flat or contoured platens, or in an autoclave.

Presses are about 5x18 ft in size, with large control consoles to record time, temperature, pressure, and steam pressure of the heating platens.

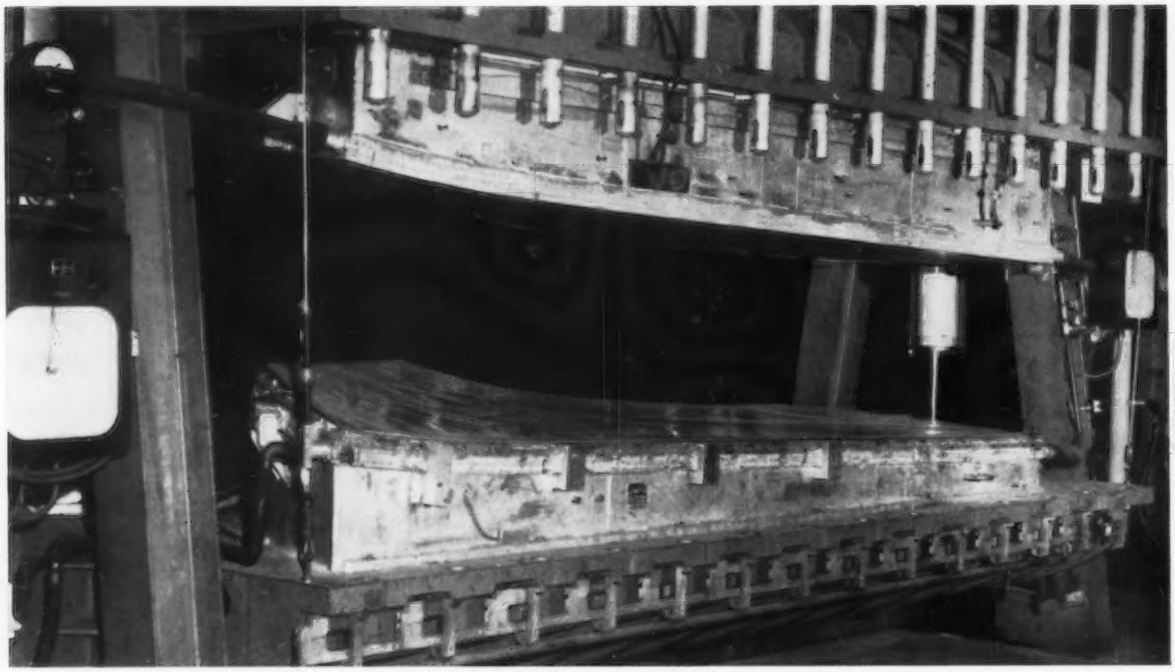
The bonding fixtures consist of two main platens, restraining rods, male and female bonding forms, and a stainless steel air bag used for applying pressure. *continued on page 25*

Infra-red heater is used for heating wing panel "slug" prior to application of adhesive.

Inner skin is installed on integrated slug of tail fin. Film adhesive has been sized and applied over honeycomb core.

Hustler . . .

continued



Presses with contoured platens are used in bonding wing panels.
Hustler wing construction consists of eight major build-up bulkheads and a series of span-wise spars covered with the honeycomb panels in huge wing bucks.

The plates forming the faces of the bonding forms are internally machined and serve as a heat manifold. Indexing or nesting provisions are also provided on the bottom form to permit accurate location of the various sandwich panels.

The outer surface of the assembly to be bonded is always adjacent to the lower platen, thus providing an aerodynamically smooth surface. Although the two platens have approximately matching contours, the requirement of precisely-matched, expensive dies is eliminated by using the air bag to provide a uniform bonding pressure over the entire panel.

After bonding, the platens are cooled by circulating water through their cores. The press is not opened until panels reach room temperature.

Severely contoured panels, wing leading edge, and similar parts are more readily bonded in an autoclave. Since heat and pressure is applied uniformly in all directions in this method, the tooling is greatly simplified.

The autoclave bonding fixture is a platen formed to the shape of the outer skin, reinforced to support its own weight and to maintain freedom from warping. A flexible blanket is placed over the assembly and bonding form, which is then evacuated to avoid entrapment of volatiles. Bonding is accomplished in the autoclave, using steam for heat and air for pressure. Most autoclave bonding is done at 350°F under 150 psi for 2 hr.

Inspection

Following the bonding operation, parts are sent to final inspection where the bond is checked ultrasonically. Bond lines in a particular assembly are compared to the bond lines of a standard panel. Good bond areas give a deflection of about ½ in. on the oscilloscope. Void areas give a deflection of about 4 in.

Test tabs are removed from the edges of each panel and tested to the following room temperature standards:

	Lap-Shear	Bend
Core-to-metal	2250 psi	150 lb
Metal-to-metal	4000 psi	130 lb

In general all bonded structures develop the yield strength of the aluminum alloy used. The use of adhesives is not a design limitation in this respect. The strength of the composite structure is limited only by the strength of the metal used.

Following inspection the panels are sent to the machining area for final clean-up of the periphery and for counterboring at the attaching points. No sub-assembly operations are required from this point for the wing panels, instead they go directly to the wing bucks for major wing assembly. At wing assembly the spars and bulkheads forming the sub-structure have been previously built into a skeleton frame work. To reduce scratches during assembly, protective paper is used in all areas of the panel except where access is required, such as at the attachment points.

◆

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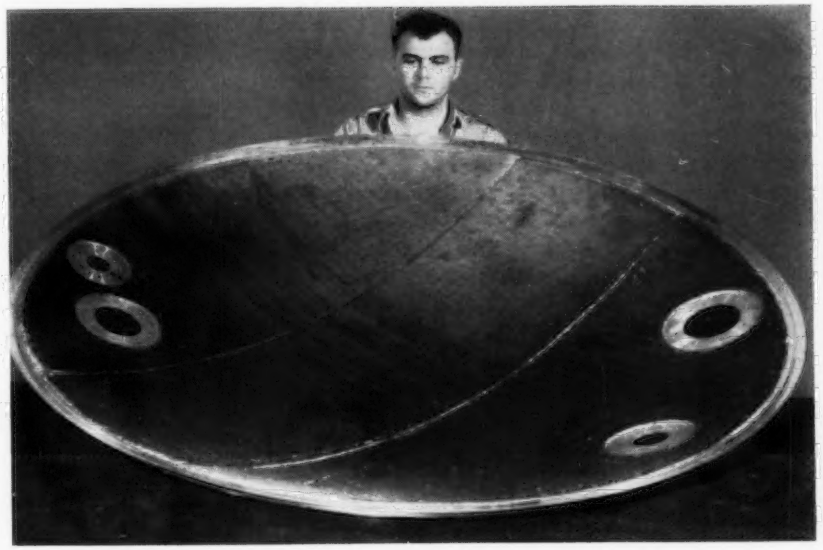


Spherical bulkhead with core in place is shown before bonding.

Crusader landing gear

by Robert McLarren

The carrier-deck landing creates loads unknown in conventional airport operations. Multiply this fact by the weight and sinking speed of the world's fastest carrier fighter, mix in rigorous weight-saving requirements, and you have truly complex design and manufacturing problems.

Menasco Manufacturing Co., Burbank, Calif., sought the solution to these problems by combining two developments: one of the highest heat treats yet used in landing gear parts, and plated aluminum. The successful results are already being applied to the gear-equipped recoverable Chance Vought's Regulus II missile, soon to enter operational service.

The tension and drag struts in the aircraft landing gear have always been simple tubes which maintained the proper radii for rotation of the wheel axle as the shock strut extended and compressed. Menasco and Chance Vought engineers, in their search for weight saving, put these idle units to work in a pioneering idea: filling the tubes with hydraulic fluid or air under pressure. The result was the location of the F8U power-control hydraulic system accumulator in the upper half of the tension strut.

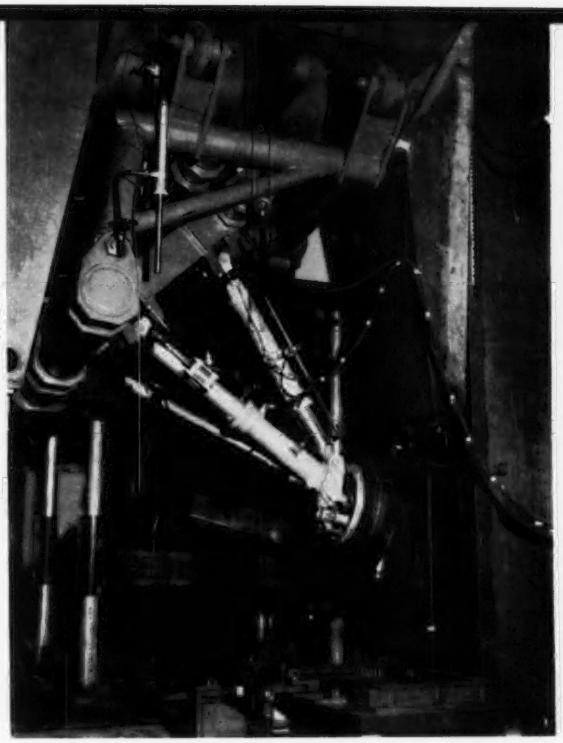
Shock Strut Cylinder

Landing impact is absorbed by metering hydraulic fluid under the pressure of an advancing piston within the shock-strut cylinder. The shock-strut cylinder contains a diaphragm which supports the orifice through which the fluid passes. Machined from a 4340 chrome-molybdenum steel forging, this strut has recesses in both ends separated by a solid area for the diaphragm.

The high stresses under which the landing gear operates make it necessary to machine all-over to insure removal of scale, pits and other stress-raisers; therefore, production planning makes no attempt to use precision forgings or other machine-time savers in confining machining to minimum-tolerance areas. The as-purchased forging is washed and placed directly on a lathe for rough-turning on both inside and outside diameters.

The partially-finished forging is heat-treated at 1500° F, for 15 to 25 min followed by oil quench at 140° F. After quenching, the forging is frozen at —90° F, for 15 min, in order to dissipate any retained Austenitic structure. The

Its nose wheel retracted and main landing gear half way nested in fuselage wheel wells, an F8U-1 Crusader takes off. The aircraft is rated at over 1000 mph and is in production for the Navy at Chance Vought in Dallas.



Complete landing gear, instrumented for load recording, is mounted in this drop test facility. Spinning wheel strikes impact plate (lower right) to simulate carrier deck landing.

high strength and reduced weight achieved through Menasco-Vought teamwork

shock-strut forging is then allowed to reach room temperature, and is drawn at 400-450° F for four hours. It is aircooled to room temperature and again drawn at 400-450° F. This heat treatment carries the forging to 260,000 psi minimum and 280,000 psi maximum ultimate.

This unusual pre-machining heat treatment is necessary to produce the very high-precision finishes required for the part, and to insure removal of decarburization. An index to the toughness of the machining job is seen in the fact that this heat treatment produces a hardness of 50 to 54 on the Rockwell "C" scale. The cylinder is then turned to 4.2-in. O.D., with a tolerance of +0.005 and —0.000 over its 24-in. length. The interior is then finish-bored to 3.98 in., with a tolerance of +0.010 and —0.000 for 14 in. in from one end and 9.5 in. from the other. Concentricity of O.D. and I.D. is held to 0.005 TIR.

Following finish-boring, the outside is turned to ±0.004 by profile engine lathe, and the "steps" along the exterior of the cylinder created. The bore is then internally ground to a 32 rms finish. The threads are cut for the end fittings by single-point turning: a major accomplishment with such high heat-treat steel. The bore is honed to a 16 rms finish and the various keyways milled in. The cylinder is then magnetically-inspected and the magnetic oxide washed off preparatory to painting. An epoxy-resin primer is baked on and the forged aluminum end-cap assembled. The finished assembly is given a white epoxy paint coating for corrosion protection.

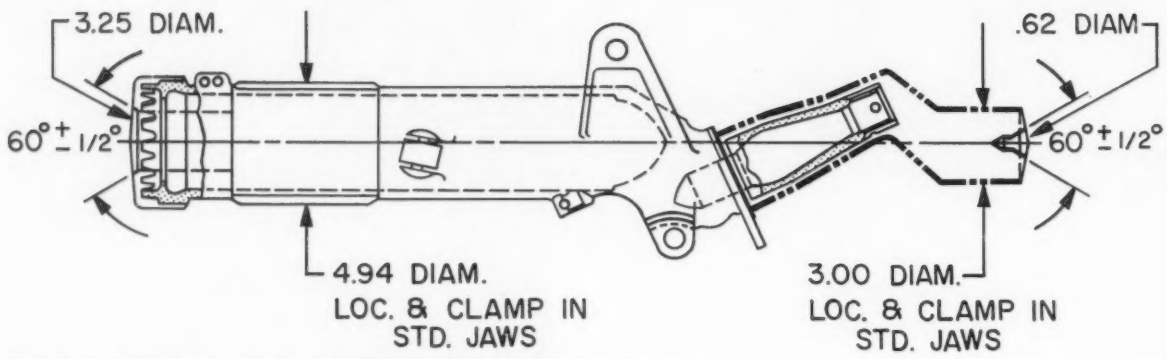
Piston Unit

Menasco also contributed to the weight-saving requirement for the supersonic *Crusader* by undertaking to produce the shock-strut piston from aluminum. The poor wear-resistance of aluminum has long prohibited its use in such applications, but an effective hard chrome plating was developed for this purpose.

The piston is 7075-T6 aluminum alloy extruded to form a head and barrel section. Machining was performed at Menasco by sequentially turning the outside and boring the inside in a series of three turning and two alternate boring operations. In this way, the material is progressively "worked" without severe distortion. The

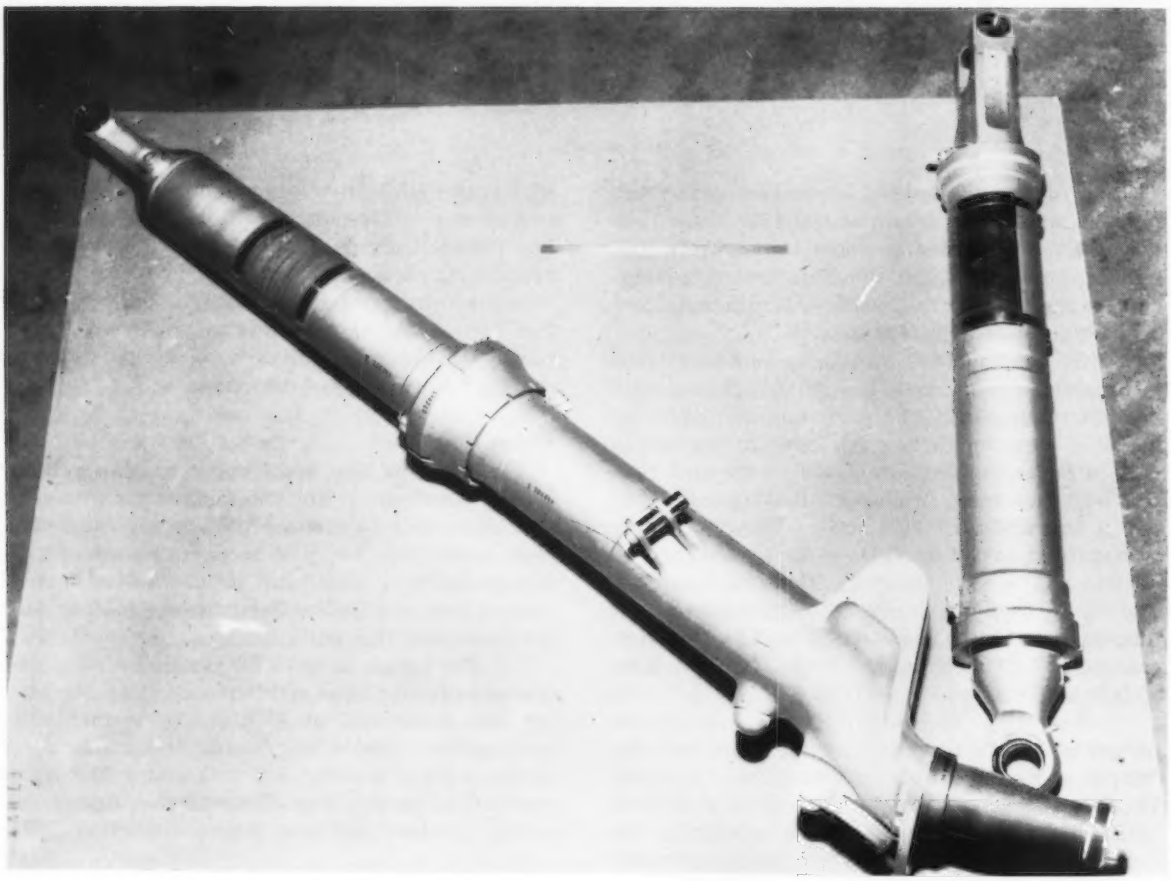
continued on page 29

Crusader landing gear continued



Dog leg in lower tension strut posed difficult lathe centering problems until second dog leg was added to forging to permit machining. This rough extension is cut off after machining is finished.

Steel accumulator (upper left) and chrome-plated aluminum barrel are joined by mechanical joint (center) to comprise tension strut. Aluminum piston rides in steel cylinder to make up shock strut unit (right).



piston is then ground on the outside to a 16 rms finish prior to plating. Hard chrome plating is applied to a thickness of 0.00525 in. The plated piston is then finish ground to a final tolerance of +0.0015 and —0.000 in.

The metering pin, threaded into the top of the piston and riding through the diaphragm hole in the cylinder, is the automatic controller of load absorption, and its complex shape is the subject of extensive computation plus dynamic testing of the completed gear. It is ground from a 7075-T6 aluminum alloy hexagonal bar, and profiled to a diameter tolerance of +0.002 and —0.000 in. and a longitudinal taper angle controlled within 0.002 in. in 4 in.

Tension Strut

The tension strut, containing the aircraft accumulator, posed unusual design and fabrication problems. The accumulator comprises a high-pressure air reservoir with associated high-burst pressure strength requirements. As an integral part of the landing gear, the accumulator must sustain tension loads as high as 113,000 lb and torsional loads of 135,000 in.-lb. These loads, in combination with a 12,000 psi burst pressure requirement and the minimum weight requirement, made it mandatory to use 4340 steel heat-treated to the 260,000-280,000 psi range.

The lower portion of the strut, containing the dog-leg into the axle, is machined from 7075-T6 aluminum-alloy forging for weight saving. The dog-leg comprising the axle at the lower end of this unit posed lathe-centering problems, which were solved by adding a second dog-leg to the forging to bring the lower end in-line with the upper for chucking. After final machining, this extension is cut off and discarded.

A challenging design problem was created at this point: that of joining a steel cylinder and an aluminum cylinder, subjected to severe torsional loads, in axial alignment. Menasco engineers solved the problem of transmitting tortional loads along the joined column by fitting both cylinders with gear teeth. The tooth-end segments are thus meshed in a tight fit, providing smooth torsional load transmission. The dissimilar metals problem was solved by anodizing the aluminum portion and the use of epoxy primer coating of the teeth prior to assembly. The meshed gear portion is covered by a threaded collet. This provides the required tension load transmission and serves effectively to seal the joint against salt spray.

The shock and tension strut end fittings are bored out to a limit of 0.001 in. on a 3-in. diam. Manganese-bronze bushings are then pressed into place. These bushings meet strenuous bearing strength requirements supporting the trunnion pins in the airframe fittings.

Test Program

Following assembly, the complete shock strut is placed in a cycling press and compressed to 300 psi pressure at 20 to 30 cycles, to check "O" ring seal for leakage. The tension strut accumulator is tested to 6000 psi proof pressure prior to acceptance.

Menasco utilizes the largest landing gear drop test facility currently in operation in the West. Landing gears tested are attached to simulated airframe fittings, and dropped from 10 ft under loads as much as 100,000 lb. Wheel spin-up loading is obtained by belts riding in pulley grooves attached to the airplane wheel and driven by an automobile engine. The belts automatically disconnect when the "down" motion commences. The test unit is released from a height varying with each aircraft specification and the entire weight taken by the gear. Side loading of the F8U main gear is eliminated by mounting the impact platform plate on greased balls, permitting it to move laterally with freedom while sustaining the vertical load.

Packaged Gears

The rapid technological progress of Menasco engineering has created a landing gear design capability permitting the company to contract complete engineering and manufacturing of landing gears, including the installation of wheels, tires, brakes, plumbing and wiring. The first such "package" contract is for the Lockheed *Electra* turboprop transport (AMM, Jan. 1958). Menasco also is currently in production on landing gears for the Boeing KC-135 and 707, Convair B-58, Convair F-102/106 interceptor (AMM, April, 1958), Lockheed C-130 cargo transport and the Lockheed F-104 interceptor. ◆

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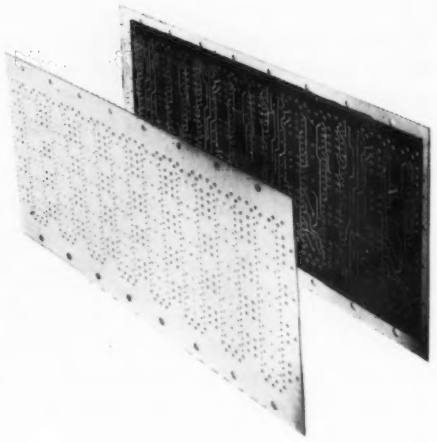
printed wiring-boards for SAGE



eight boards made simultaneously using "dry screen process," simple manufacturing techniques help assure reliability

Thousands of printed wiring-boards are used in producing the SAGE (Semi-Automatic Ground Environment) computer. High reliability of the circuits is essential to the proper utilization of the equipment, and to this end the manufacturing process has been kept simple.

Basically, the process is to pierce copper-clad phenolic laminates and sensitize the pierced holes for plating. Actual printing of the wiring boards is accomplished by the "dry-screen process" in which a plating-resist is applied to the copper sheet conforming to the circuit pattern.

The dry-screen process gives high quality panels, and eliminates the baking operation essential in conventional screening processes. Handling of the panels is reduced and production rates are increased.

Processing Details

Copper-clad laminated phenolic sheets 9 x 18 x 1/16 in. are purchased by the circuit manufacturer (International Business Machine Corp.); eight printed wiring-boards are produced from each sheet.

Holes for mounting the electrical components in the circuit board are pierced with a punch-press, holes in the pierced sheet are sensitized for electroplating by dipping the panel in a solution of graphite and alcohol, and passing the sheets through rubber rollers to remove excess solution, prior to oven-drying. After removal from the oven an automatic sanding-machine removes the excess graphite leaving a coating only on the walls of the holes in the sheet.

A coating material inert to plating (plating-resist) is then deposited on the area of the panel not to be plated, by placing an image-screen on the sheet and passing a squeegee over the layup. The resist is applied at 160° F and dries almost immediately on contacting the copper-clad laminate. The operator flips the sheet over and repeats the process, placing a plating-resist on the opposite side. The sheets are then racked for plating.

The racked sheets are copper-plated to provide continuity of copper through the sensitized holes. A second plating process deposits a layer tin-lead composition on the same unmasked

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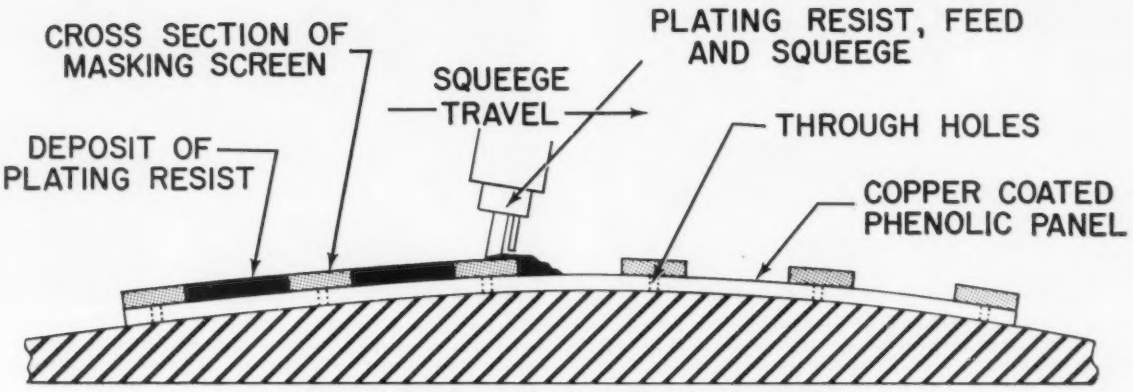
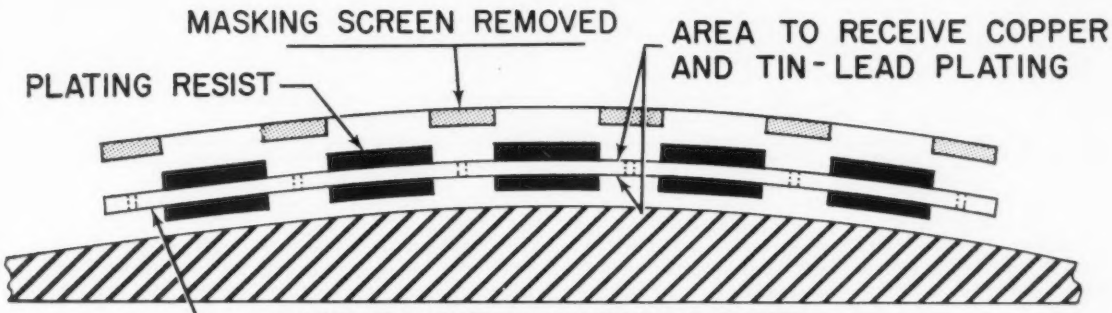
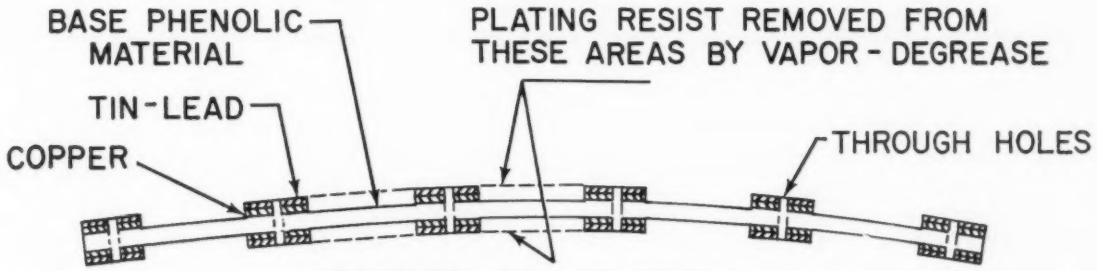
SCHEMATIC PRESENTATION OF DRY SCREEN PROCESS



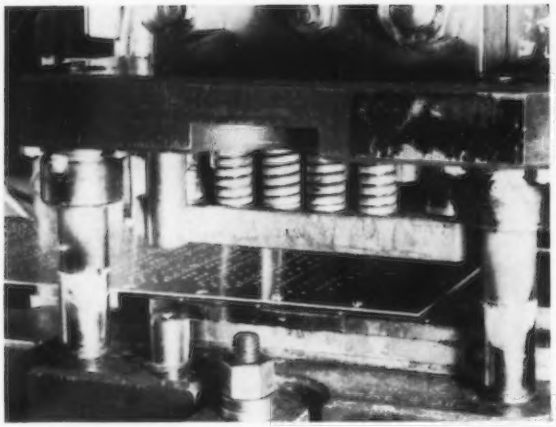
APPLICATION OF PLATING RESIST
(SHOWN IN CROSS SECTION)



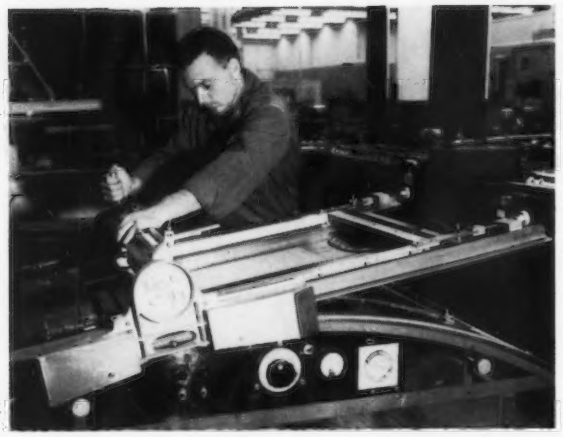
COPPER COATED PHENOLIC PANEL
WITH PLATING RESIST SHOWN
APPLIED TO BOTH SIDES



FINISHED CIRCUIT PANEL
PLATING RESIST IS REMOVED BY VAPOR DEGREASING AND ORIGINAL COPPER CLAD IS REMOVED BY CHROMIC ACID ETCH
REMAINING COPPER & TIN-LEAD CIRCUIT AREA INERT TO CHROMIC ACID ETCHANT



Copper-clad phenolic sheets are perforated on a punch press. Holes are later sensitized with a graphite-alcohol solution and electroplated. Eight printed wiring-boards are made from each copper-clad phenolic sheet.



Circuit pattern is deposited on the copper-clad phenolic using the "dry-screen process." A screen is laid over the copper sheet and a plating-resist applied to areas that are not to receive subsequent deposition of Cu and Sn-Pb.

printed wiring-boards for Sage

continued

Many will agree that "the best defense is a good offense," they will also agree that an effective defense is necessary to detect and blunt an enemy air offensive by aircraft and missiles.

Taking into consideration our national policy of not striking until struck, the importance of being able to prevent a surprise enemy attack is paramount. If we are to prevent a crippling blow, we must have a highly refined early warning electronics capability to allow us to put our bombers and missiles into the air and on their way in retaliation. In the face of an overwhelming and diverse enemy offensive, we cannot depend upon our defensive weapon systems — both manned interceptors and guided missile weapon systems—to achieve a 100 per cent, or perfect defense.

The complete defense system must detect, identify, track and then assign and control weapon systems to the interception and destruction of the enemy weapons.

Obviously, this complex electronic ground environment must work continuously, reliably and quickly because of the speed of present day weapon systems. Such an integrated system must collect and present information at a high rate of speed. The problem, therefore, surpasses human capability. This is where the SAGE system comes into the picture. SAGE is the Air Force development to provide a quick-reaction detection and control system within the U. S. proper.

The SAGE system ties together all of the data input sources, including the vast network of radars of various types, to electronic brain centers.

Information from such sources as Texas Towers, height-finding radars and airborne early warning ships is transmitted through telephone lines to computer centers where the information is collected and correlated, and presented to the human operator who makes the operational decision. Then automatically, commands are transmitted to the proper weapon systems which are directed to the interception.

areas. Both sides of the sheet receive the copper and tin-lead plating on the surfaces not covered by the plating-resist.

Next, the resist is removed by vapor-degreasing, and the previously masked area exposes the copper of the base phenolic sheet. The exposed copper is removed by a chromatic-acid etch leaving only the phenolic-base material in the non-conductor areas of the circuit. In this phase, the tin-lead plating in the holes and on the conductor pattern acts as an etching-resist. The finished boards are then blanked from the sheet.

Preferred and prepared components are inserted in the holes on the board and the assembly is dip-soldered. The complete component is inspected and tested before installation in one of the pluggable units of which a large part of the SAGE computer is composed.

✦

Extracted from a talk by Lt. General S. E. Anderson, at AFA Jet Age Conference.

Vickers Vanguard features

double-bubble fuselage compartmented
by beam-supported deck for both passenger and cargo
torque-box structure of wing provides
integral fuel tanks

by Ronald A. Cole

After the Viscount had been established as a successful airliner, the makers, in cooperaton with British European Airways, undertook design studies of a development aircraft. Everything that affected operators was reviewed and reworked for maximum flexibility, economy, and overall serviceability. To these ends the novel method of starting a design with the cabin and freight compartments was adopted. Only when the design of these two items was frozen did work begin on the airframe structure.

Design and Safety Features

Although the Vanguard structure is orthodox it has some unusual facets by way of alternative load paths which give "fail-safe" characteristics. This is exemplified in the wing structure which consists of a two-cell torque box built around three vertical shear-webs. No less than 54 milled skin-stringer panels cover this box.

Stresses in the cabin skinning have been limited to 12,000 psi. Around doors and cut-outs half the loading is carried in the reinforced plating, and the remainder by substantial boundary members. Where web cut-outs appear in highly-stressed areas, oval rather than circular forms are used. For the same reason cabin windows have a deep oval shape.

Single heat-treated alloys are utilized for parts in tension. The wing top skin is of DTD 5020 (Directorate of Technical Development specification), whereas the lower is of American 2024-T4 aluminum alloy. Sudden change of section, the use of bolts in tension, and single-pin joints have been avoided wherever possible.

Aerodynamic Aspects

Wind-tunnel tests, on both low and high-speed models, show that the modified NACA 63 series section, as used on the Viscount, provides optimum performance. This is despite a skin joint, at a small percentage of the chord, which impairs the otherwise extensive laminar flow region attained with such sections. A planform of broken taper with little or no sweep in the span of 118 ft is used. Its aspect ratio is a little over 9:1. Thickness-to-chord ratio decreases from 15

continued on next page

Vickers Vanguard

continued

per cent at the root to 13 per cent at the tip. Fowler-type flaps extend over some 60 per cent of the span, and are in eight sections.

A small drag penalty is associated with the double-bubble fuselage cross section. The makers state that a circular form would increase cruising speed by 5 mph and the ship would weigh 1000 lb less. Another unavoidable penalty is incurred by the bulged wheel-housing on the inner nacelles. This is necessary because the wing is continuous without cut-outs for wheel retraction.

VICKERS-VANGUARD SPECIFICATIONS

Span 118 ft
Length 122 ft 10.4 in.
Gross area 1529 sq ft
Max take-off weight 141,000 lb
Design payload 25,000 lb
Max landing weight 114,000 lb
Design cruising speed 425 mph at 25,000 ft at 13,500 rpm and fuel consumption of 0.388 lb/hr/ehp
Typical maximum payload 86 passengers with baggage, plus 7800 lb of freight

Wings

The main wing structure is a two-cell torque box built around three vertical shear-webs. It is not accurate to call these spars since bending moments are carried in the integrally-milled, skin-stringer panels. Attached to this box are the detachable leading edge, the aileron fairings, and the flap shrouds. Brackets carrying the flap guide-rails also cantilever out from its rear face. The wing is split into three main parts; a short center section spanning the fuselage, and two mainplanes with jointure just outboard of the outer engine nacelles.

All the milled skins are made from panels stretched 2.0 per cent ±0.25. Panel surfacing is carried out on a Cramic machine with a 20-hp head driving a 12-in. diam face-mill at 3000 rpm. Because the panels are not sufficiently flat during this first operation a special vacuum chuck with safety hooks is used. Hogging-out the stringer runs is done on an Onsrud A90 spar miller with two motors in tandem, providing 80 hp at 3000 rpm. The force exerted on the panel causes it to lift at the edges. Mechanical edge-clamping is used to augment the normal machine clamps. Edge profiling, rabbeting and other finishing operations are done on a Cramic profiler. Because the DTD 5020 panels for the top skin grow during precipitation treatment, this is done after the roughing stage. Finishing cuts are made on the fully treated metal.

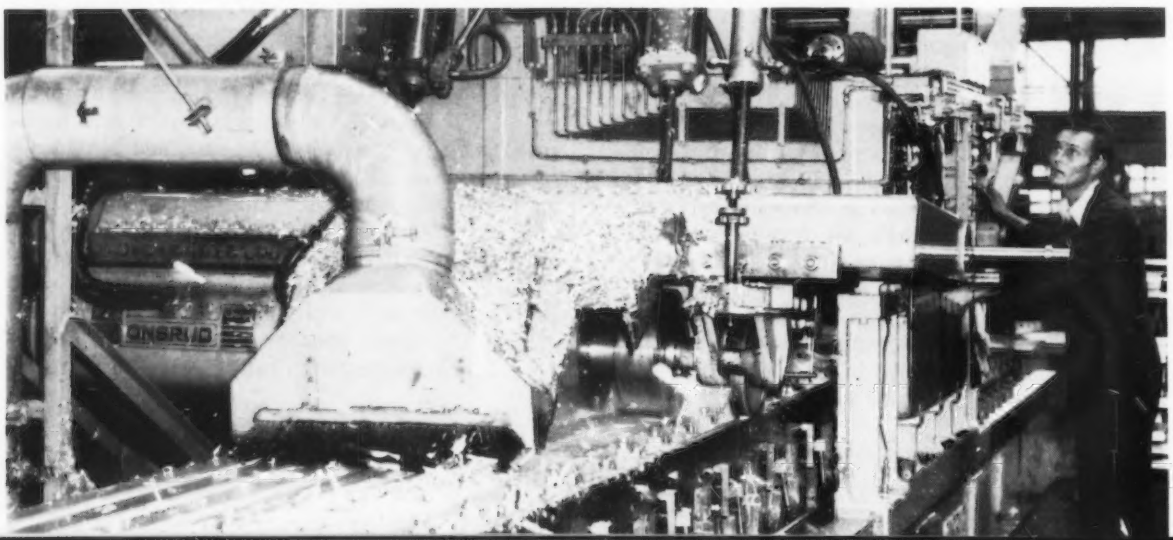
Curvature on the outer wing skin-panels is obtained by shot-peening, using 0.011-in. diam shot. Curvature is controlled by the rate of feed of the shot. Where hot forming is necessary, it is done between electrically heated platens. Jigs for wing components are built up on light alloy rafts to avoid differential expansion between jig and assembly.

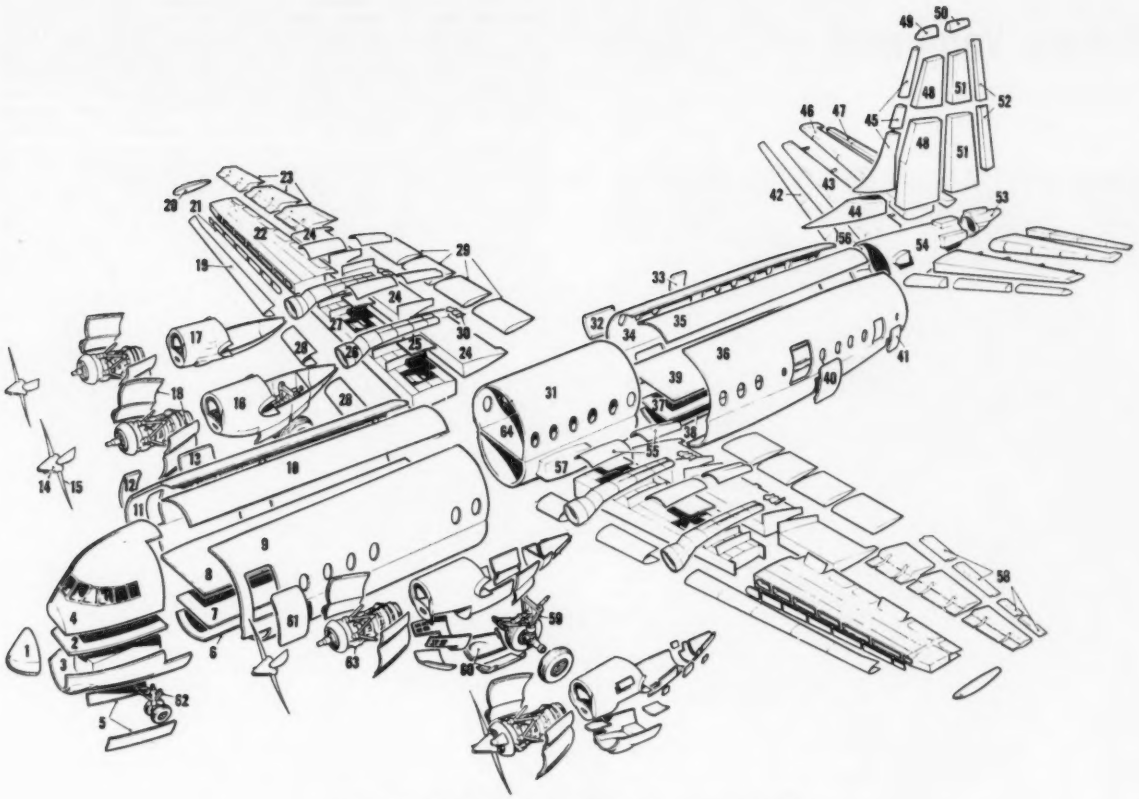
With the exception of the center section, practically the entire wing torque-box forms an integral fuel tank. There are two tanks over the power-plant section, and a third over the outer span almost to the tips. All the inboard ribs, except those forming tank ends, are pierced by large oval holes that provide continuity of volume as well as access. Similarly, the center shear-web is pierced and has heavy reinforcement rings around the holes. Large removable panels in the top skin allow inspection. The whole leading edge "D" assembly can be removed for outer-tank servicing. The leading edge has a light shear web to maintain rigidity when separated from the wing.

Fuselage

By using a double-bubble cross section substantial headroom over both passenger and freight floors has been obtained. The freight floor is ▶

Hogging out the integral stiffeners with an Onsrud A.90 miller. Sufficient cutters and arbors are available to allow one setup for each operation on this machine.





KEY TO VANGUARD STRUCTURAL BREAKDOWN

1. Nose Radome
2. Pilots' Floor
3. Nose Fuselage Bottom Structure
4. Canopy
5. Nose-wheel Doors
6. Forward Fuselage Bottom Panel
7. Forward Fuselage Freight Floor
8. Forward Passenger Floor
9. Forward Fuselage Side Panel, Left Hand
10. Forward Fuselage Top Panel
11. Foward Fuselage Side Panel, Right Hand
12. Crew and Servicing Door
13. Forward Freight Door
14. Spinner
15. Propeller
16. Inboard Nacelle
17. Outboard Nacelle
18. Petal Cowling
19. Outer-wing Leading Edge
20. Wing Tip
21. Outer-wing Fuel Tank Access Panels
22. Outer-wing Main Structure
23. Aileron
24. Inner-wing Trailing Edge Structure
25. Inner-wing Fuel Tank Access Panels
26. Jet Pipe
27. Inner-wing Main Structure
28. Inner-wing Leading Edge
29. Flaps
30. Jet Pipe Drip Tray
31. Fuselage Center Section
32. Rear Freight Door
33. Rear Servicing Door
34. Rear Fuselage Side Panel, Right Hand
35. Rear Fuselage Top Panel
36. Rear Fuselage Side Panel, Left Hand
37. Rear Fuselage Freight Floor
38. Rear Fuselage Bottom Panel
39. Rear Passenger Floor
40. Rear Passenger Entrance Door
41. Emergency Exit Door
42. Stabilizer Leading Edge
43. Stabilizer Main Structure
44. Dorsal Fin
45. Fin Leading Edge
46. Elevator Main Structure
47. Elevator Tab
48. Fin Main Structure
49. Dielectric Fin-Tip
50. Dielectric Rudder-Tip
51. Rudder
52. Rudder Tabs
53. Tail Cone
54. Rear Fuselage
55. Jet-Pipe Shrouds
56. Rear Pressure Bulkhead
57. Wing Center Section
58. Aileron Tabs
59. Main Landing Gear
60. Main Landing Gear Doors
61. Forward Passenger Door
62. Nose Gear
63. Power Plant
64. Center Passenger Floor

stressed to carry a local load of 200 psi with a general loading of 150 lb/sq ft. The cabin floor is continuous from the cockpit to rear pressure bulkhead while the freight floor is separated under the wing center section.

Upright "Z" section stringers spaced at about 5-in. intervals run around the periphery of the fuselage, with the number being reduced towards the tail. Shallow channel-section rings provide the cross-sectional shape. These vary from the floating type, which lay atop the stringers, to the notched variety that are riveted to the skin between the stringers in the more highly stressed areas. Passenger floor level coincides with the bubble intersection line. Pressed-plate fittings, riveted to the lower rings, cantilever out to mate with the channel-section cross-beams which support the floor. Two heavy built-up beams run along the fuselage, flush with the floor panels. On their underside heavy buttress-fittings carry freight-lashing rings at ceiling height in the cargo bays.

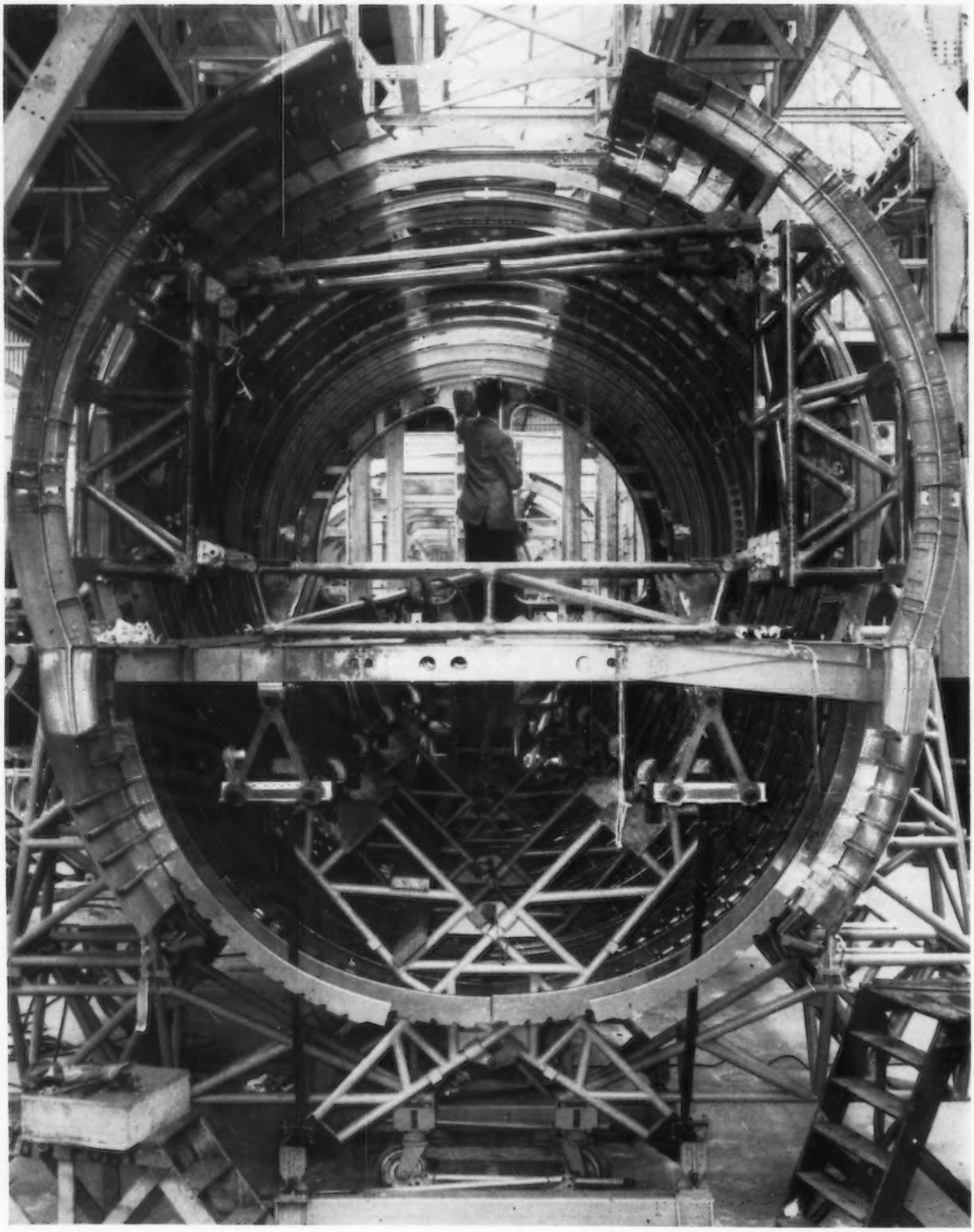
Both the wing and fuselage center sections form a single closely-integrated structure which remains in its gantry-type erecting frame while

continued on next page

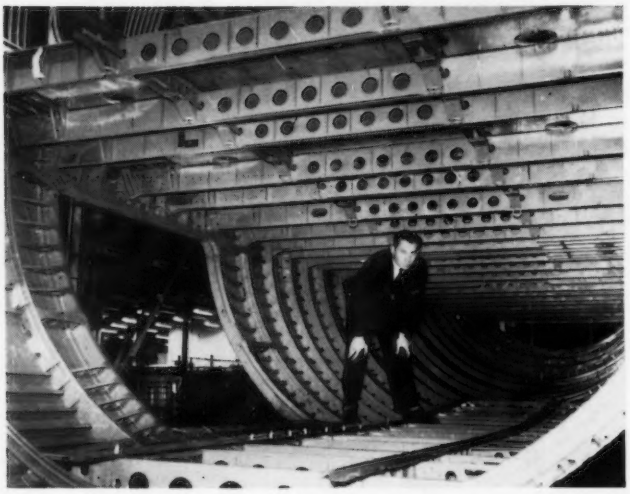
Vickers Vanguard

continued

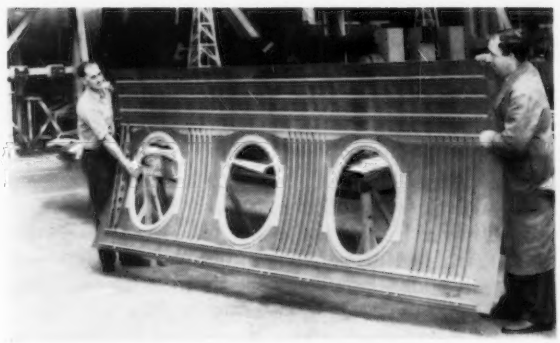
The trusses holding the transverse floor beams in position can be seen along with the supporting frames, which are pinned to the floor and where they cross each other. Cross tubes above the passenger floor and a split cast ring at the far end of the section give exact location of the side panels which are supported by mobile trolleys. Top and bottom skin panels are added in the finishing stages of assembly.



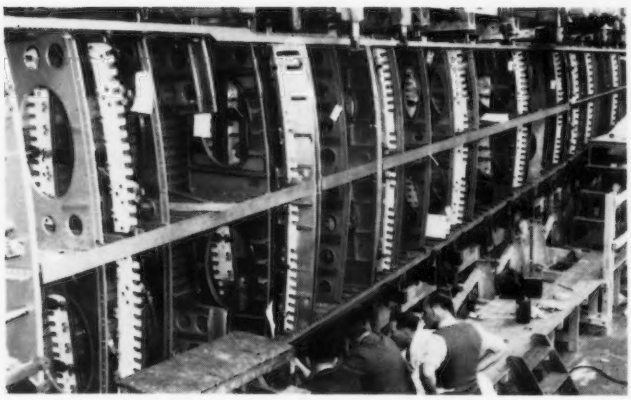
Headroom in the freight hold is 4¼ ft. The heavy buttress fittings holding the lashing rings can be seen in the roof. Note also the size of the freight door to rear hold, another of the same dimensions gives access to the front hold.



Being held upside down by two workmen is a window panel. The small stiffeners between the window holes are Redux-bonded to the skin and have the function of increasing the cross-sectional area resisting hoop tension.



Wing panel in its vertical assembly jig. The three shear webs with their light booms are seen together with the pierced ribs. The inboard end is nearest to the camera.



front and rear sections are added. The large fuselage assemblies consist of two side panels connected by top and bottom skin panels, and the lateral floor beams.

During fuselage sub-assembly manufacture, two substantial trusses hold the floor beams in position and are supported on pairs of simple frames. The frames are pinned to the floor and to each other where they cross. Like the trusses, they are made of welded steel tube. The complete fuselage sides, consisting of skin and half-frames, are placed in joining position with the aid of cross tubes and a split cast-ring hinged from a gantry. After the sides have been joined, pins are extracted from the "X" frames and withdrawn through an aperture, closed later by the bottom skin panel. The wheel-about, holding jigs remain attached to the complete section providing mobility for transport to the main mating position, and serve as adjustable supports for that process.

Window apertures appear in a panel which extends from the cabin floor to two stringers above the cut-outs. Between the windows there is a series of small stiffeners Redux-bonded to the skin. Thus, cross-sectional area is increased to resist hoop tension; panel stiffening is a secondary function. Pressed segment-frames are employed to join the lower ring frames and provide a flat base for the freight floor.

The less highly stressed members such as small stiffeners, some stringers, doubler plates and cut-out reinforcements are Redux-bonded to the skin. Most of the bonding is done in autoclaves. Wherever possible assembly work has been arranged to allow erection from the skin line inwards. Also, to reduce development time, there is no prototype aircraft. The first aircraft is being made in the production jigs. At present, this is an unusual procedure for the United Kingdom, but it may become standard on all except research aircraft.

Power-plant Installation

Initial output of the Rolls-Royce Tyne turboprop engines will be 4020 shp. Projected development should improve this to 4880 shp by 1961. Later versions, to be available in 1963, will produce 5245 shp. Taking residual thrust into account, total horsepower will be 5750. Most of the power increase will be the result of improved combustion efficiency and turbine disks, allowing higher inlet temperatures. Unofficially, it is thought that the use of titanium alloys and air-cooled blades will play an important part in the engine development program.

Each powerplant is mounted well ahead of the leading edge on a semi-monocoque nacelle structure built on the wing torque box. A tubular framework supports the engine behind the main compressor casing and picks up on the firewall

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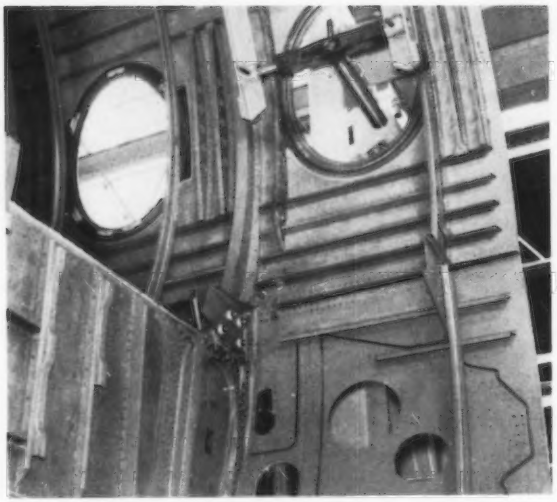
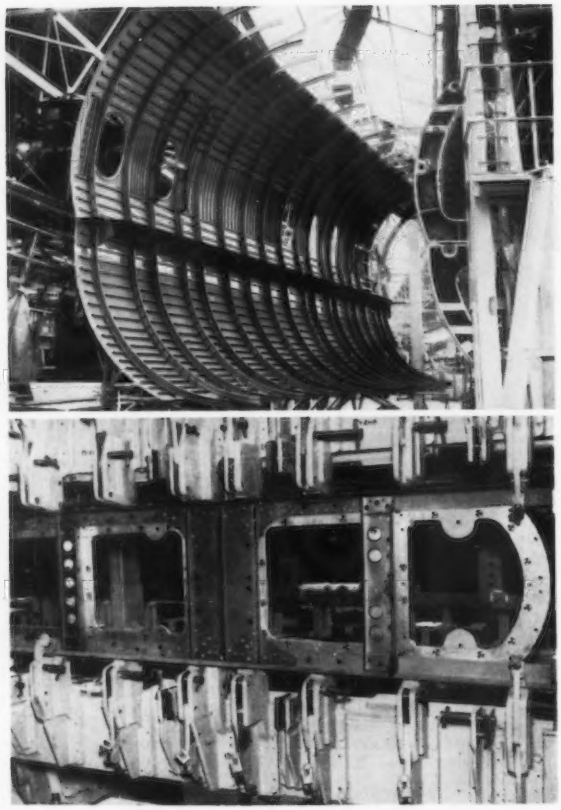
Vickers Vanguard

continued

A complete side panel ready to be wheeled into position. The cantilever plate fittings to hold the floor cross beams are seen.



A close-up of a wing-fuselage joint showing a doubler plate and small stiffeners Redux-bonded to the skin and reinforced by rivets. The fitting cantilevered out from the frames will anchor the transverse floor beams.



Over the outboard portion of the wing the front shear web is removable in sections to provide access to the outer tank interior. This view shows the inner side of the frame to which the sections are bolted.

face. Exhaust ducts blend upwards and over the wing contour to the trailing edge. The Tyne engine has a high pressure-ratio of around 13:1 which allows excellent fuel economy but demands a two-spool compressor. Each compressor spool is driven by its own turbine. The one powering the low-pressure spool also drives the propeller. A compound epicyclic reduction-gear is specially-mounted to damp-out engine vibration. An important feature of the two-spool arrangement is its inherent flexibility which allows high propeller speed for take-off yet a low speed for cruise.

The accessory gear box of each engine is fitted with propeller brakes; each gear box is driven by the low-pressure spool shaft. An annular oil tank surrounds each intake casing providing engine lubricant and fluid for propeller operation. The fluid circulates through a double-matrix heat exchanger mounted beneath the engine and fed by ram air. The long nacelles keep the combustion zone well ahead of the wing. There is a fireproof bulkhead between the compression and combustion zones, shrouds cover the combustion zone and the jet pipe, and accessory bays give extra protection. Methyl bromide is stored in bottles behind each engine. If necessary, the bottle from one engine may be used to extinguish a fire in the adjacent nacelle.

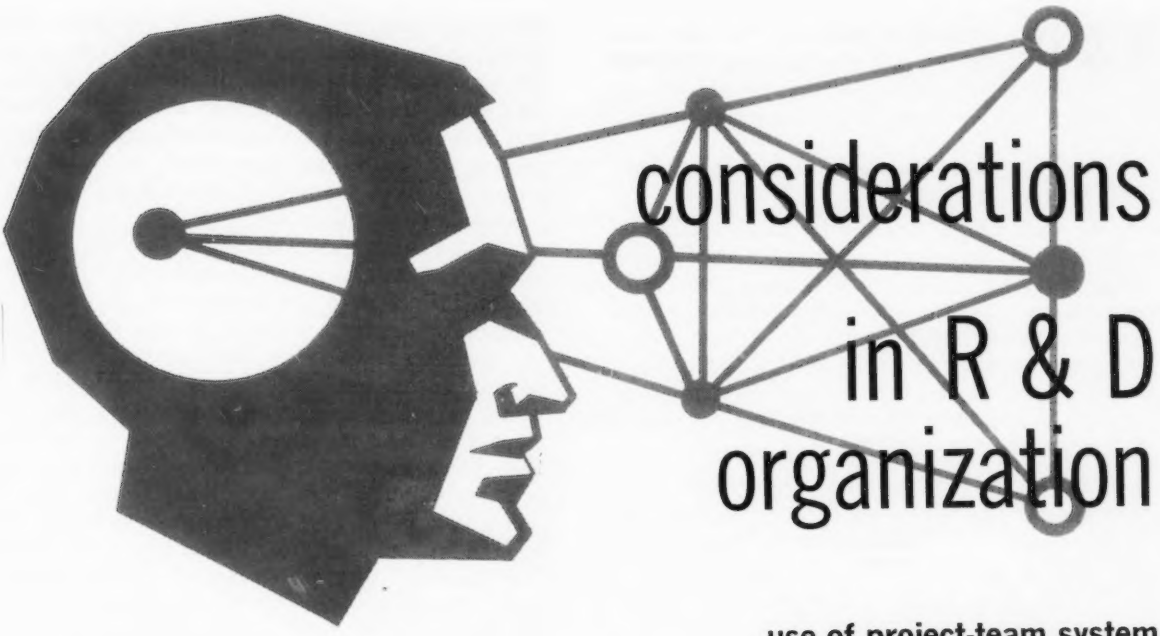
Empennage

All controls are manually operated via push-pull rods; balance, servo and trim tabs appear on all surfaces.

Like the wing the horizontal stabilizer is built around three shear-webs to which ordinary skin-stringer panels are attached. Riveting is of the flush-skin variety. Stabilizer configuration incorporates a medium-taper planform, and a thickness-to-chord ratio decreasing from 14 to 12 per cent along the span. The stabilizer dihedral angle is 15 deg.

Landing Gear

Operation of the landing gear is hydraulic, power being taken from the main 3000 psi system which also operates brakes, steering, and the entrance steps built integrally in the main doors. In an emergency the landing gear and the nose wheel can be extended to the down-lock position under the action of gravity and air drag. Wheels can be lowered at 230 mph, with considerable braking effect. ✦



considerations in R & D organization

use of project-team system increases effectiveness especially on short-range projects

by Matthew Arnold
ground systems analysis engineer
MOSD, General Electric Co.

The evolution of research and development (R & D) activities from the output of isolated individuals to the productivity of several hundred-thousand persons presently engaged, has focused attention upon the administration of this effort.

Research costs have more than doubled in the past decade. "On the average it cost $35,000 per year to pay professional scientists and give them working space, equipment, clerical help. . ."[1] The annual expenditure for industrial research is in excess of $7 billion and it accounts for more than 1 per cent of the gross national product.

The cost of labor accounts for 50 to 75 per cent of total operational costs. While this is also a function of the nature of the work, the labor cost is a prime factor in determining the cost of allied requirements. Although equipment cannot be substituted for creative intelligence, there is a greater area for replacing personnel with equipment especially in work requiring computations.

R & D work is different from other industrial pursuits. The objectives of each enterprise for this type of work vary from fundamental research in a field of science, to specific problem-solving for one customer. Therefore, the manner in which firms organize, and manner in which staff research departments operate must also vary. The purpose of this article is to survey some of the important factors relating to organization and personnel.

Organization

The key to a successful R & D organization is to establish a system which will permit individuals to apply their knowledge and abilities in the direction which is of the greatest importance to the laboratory, without completely losing the importance of the individual as a person. There probably is no one best method of organizing a research group. As the problems and the approach to problems vary so should the organizational structure.

The organization of an R & D group is a function of the objectives of the programs, the availability of personnel, the philosophy of operation's director and traditional approaches in the field. The main types of organization are: scientific disciplines, functional groups and a combination of the two as shown.

Organization on the basis of major scientific disciplines (Chemistry, Physics, etc.) is most expedient when the problems can clearly be separated by subject matter. Much exploratory research is done in this manner. In general, this type of organization is best suited for a central research or development laboratory mainly concerned with advancing the state of the art. Work

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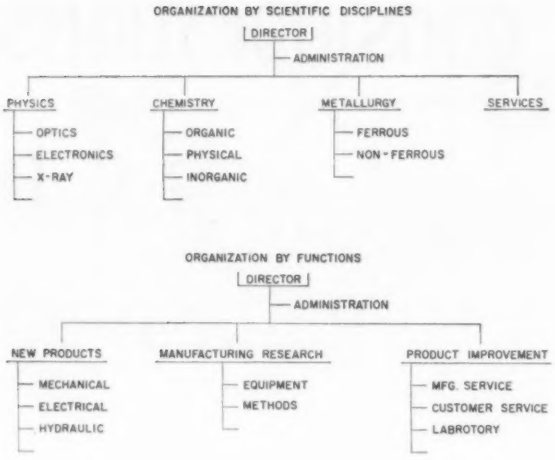


assignments are given to the group in whose area the major portion of the problem lies, and work requiring other disciplines is farmed out, under the direction of the parent group. A tightly knit, highly-specialized group tends to develop with this organization.

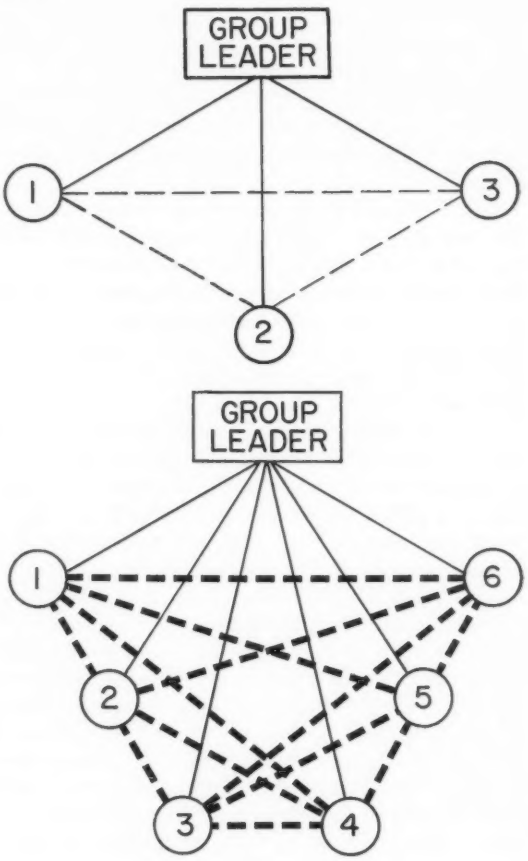
A functional organization divides personnel by end-product or process, i.e., new products, research and development, process design, plant services. This requires staffing with personnel having depth of experience in several fields so that problems can be suitably attacked. Under this system it is possible to break the staff further into subject disciplines. This grouping is more flexible for a permanent organization and is best suited to industrial development. The Budd Co. is one of many firms employing this arrangement successfully.

Industrial laboratories emphasize development work, i.e., introduction of new products or improvement of existing ones. By combining the discipline and functional organizations, the research director may be able to have a system capable of handling long and short-range problems covering several fields. Basically, the laboratory is divided into major disciplines with the addition of a "project group." The major discipline groups would essentially be charged with long-range programs and state-of-the-art assignments in their specific fields.

Members of the project group would serve as a nucleus for short-term tasks and for spearheading major programs requiring a variety of skills. Task force members could be drawn from the required discipline during the life of the program. This would serve to broaden their field of knowledge and give the team a specialist well versed in the state of the art. One very long project or a continuous stream of similar programs, may cause the team to remain essentially intact and to develop into a self-contained unit. The usefulness of the project team tends to lessen the longer the group is together unless it is continually stimulated by the leader.

A project group should be as small as possible, so that it is not over-burdened with self-initiated procedures and paper work. As its life is extended, the group tends to become unified and the members disassociate themselves from their original functional areas. For a major project it would be well to rejuvenate the team by replacement with new members from time to time to keep fresh ideas going. Project teams are for problem solving—not operational work, thus a numerical size of four to ten members should be set as a limit to team size. Fewer than four limits "self-ignition" and encourages individual rather than team effort—more than ten members reduces the team's effectiveness by requiring more control.

Most authorities agree that the number of subordinates who can be effectively supervised by one man is between three and six. As subordinates are increased in number, so are the inter-relationships.



Thus increasing subordinates from three to six increases the cross-relationships from six to twenty-one.

Span of Control

The span of control for any organization may be determined by weighing the advantages of retaining managerial responsibility against delegating it. The higher in the level of organization one goes, the shorter should be the span; with the consequent increase in delegation of authority. This will allow the higher level manager more time for managing, and will reduce the direct access to him by subordinate personnel. Some limiting practical factors to span of control:

(1) The less complex the type of work supervised, the greater will be the gains of delegation. Factory workers require relatively little supervision; thus the span of control can be large for the foreman. Research workers in general require greater technical supervision; therefore, the functional engineer should only lead a small group.

(2) Short spans of control do not provide training for subordinates in assuming responsibility.

(3) The longer the lines of control, the higher will be the cost of supervision.

(4) Managers not capable of keeping away from detail work cannot have a long span of control, neither can the working leader.

(5) The less the experience of the workers being supervised, the shorter should be the span of control of their leader.

Examples

The Talos program at the Morestown plant of R. C. A. has the following typical control span for an operation.

Manager		
Leader	Leader	Leader
6 Engineers	10 Engineers	8 Engineers
8 Technicians	16 Technicians	17 Technicians

Ratio of technical and non-technical personnel

While it is inefficient to have professional men do semi-routine or routine work, the amount of non-professional technical assistance which an individual requires depends upon the nature of his assignment. Research scientists cannot use as much help as the man who is working on specific development problems.

At the Bell Telephone Laboratories the number of professional scientists and engineers rose from 2,300 in 1946 to 3,100 in 1956. During the same period the number of technical aides rose from 400 to almost 2,000 with a corresponding ratio increase from 0.16 to 0.65.[2] The ratio for the Nose-Cone Section of General Electric's MOSD is approximately 0.9.

Technical Aides

The increased need for utilization of clerical and administrative personnel for these respective duties is apparent. However, the technical man should not be divorced from all paper work. Aside from the necessity of originating his own reports and documentation, work of this nature enlarges his understanding of the overall requirements of an operation, and to some extent serves as training for advancement to supervisory levels.

The work of the technical aide falls into many areas:

a) Design, construction and maintenance of lab equipment.

b) Evaluation of materials, devices and processes.

c) Mathematical computations and studies.

The depth of work entrusted to the aide depends upon the skill and experience of the man performing the work and the willingness of the professional to delegate responsibility.

Technicians' Pools

With regard to technicians' pools—a majority of the firms represented at a recent conference indicated a lack of success. The main reasons being that: (a) the better technicians are requested by one group and seldom made available for other groups, (b) when the overall workloads are low, the pool does not always have enough work to keep the men busy, (c) the technicians as individuals prefer to work for one or two men rather than be shunted about like a machine, (d) supervision of the men is difficult.

Advantages of technicians' pools include: fewer technicians required and the technicians get a better overall knowledge of the work—this is especially good for new men with limited experience.

Selection of Research Personnel

Some of the qualities considered essential in research personnel which might distinguish them from salesmen, administrators, production supervisors and others in industrial activities are:

- Knowledge of the scientific field
- Superior intelligence
- Ability to write reports and speak well
- Ability to produce new ideas—Imagination
- Persistence in the face of difficulty
- Curiosity and a desire to solve problems

continued on next page

- Possession of certain character traits, including honesty, generosity, self-discipline, courage and tolerance
- Enthusiastic attitude toward work
- Ability to analyze and develop a planned group attack on the problem rather than dependence upon an inspired attack
- Competence in recording and interpretation of data.[3]

The type of work to be done in a large measure determines the requirements for specific personnel. Pure research requires an individual who must be genuinely interested in science as an attainment in itself, who works on his own initiative, is not greatly concerned with the time element, and works alone or with a few assistants. Personal idiosyncrasies are not important since he is not generally required to be a "team player."

Men doing development work in conjunction with others, must, in addition to professional skills, possess personal characteristics which enable them to work harmoniously with others, must be keenly aware of the time element in their work, and be able to shift their attention for the rapid solution of specific problems. Leadership and followership are also requirements.

Morale Factor

The morale of the research and development staff is one of the most important factors in determining the success of a laboratory organization.[4]

Three important contributing factors to high morale are:

(1) Recognition of the individual's accomplishments by laboratory management, fellow scientists and engineers.
(2) Adequate salaries.
(3) Stability of organization, a continuous flow of challenging work, proper work conditions, and good equipment.

The individual is the smallest unit for any task, however, the parameters of time requirements for completing a research or development assignment, the extension of problems into many disciplines, and the necessity for intense knowledge in a specific field, have necessitated that the group approach to problems is the most practical, especially in applied research. For this reason a greater emphasis is being placed upon the ability to get along and communicate with others. Men who are only average when working alone may become more able by the mental stimulus provided by association with other men on similar problems.

A large portion of current R & D work is being conducted by relatively young engineers. This is especially true in the aircraft and electronic fields. Managers must exercise judgment in assigning these men to tasks without sufficient experienced personnel to guide them. These men "have the greatest need for knowledge of what has been done in the past. It has been noted that the reinvention of discarded ideas follows a cyclical period of something like eleven years.[5] Therefore, the value of experienced guidance should not be overlooked.

Certain Conclusions

During the American Management Association seminar on Laboratory Organizations in February 1957, participants representing firms engaged in military, consumer, durable and capital goods reached the following conclusions regarding research personnel:

The problem of parallel advancement is a major one in many organizations. Some men are capable of advancing to supervisory and administrative posts with the accompanying rewards of status and pay. Other men deserve recognition, but because of lack of suitable openings or personality problems, cannot be advanced in this manner. The General Electric System of announced specialist personnel was cited as a suitable solution. Also recommended were special titles, the use of a private office, executive privileges and status awards.

Overriding all organization problems and solutions is the factor of individual personality. The inherent differences of persons seems more highlighted in the confines of the research and development organization than in production groups. It was felt that the main task of a senior research manager should be the integration of personnel into the work situation. Several senior executives indicated they spend at least half of their total time on personnel problems.

Measuring Research Personnel Effectiveness

There does not appear to be any objective manner to determining whether or not too many or too few personnel have been assigned to a problem. To some extent research can be done on a timetable, however, unlike piece work in an

assembly plant, the addition of a given number of people will not always increase productivity. The subjective evaluation of experienced managers of research work is the most widely used method for appraising this problem.

One manner in which a better feeling for this problem can be obtained is to break the total work assignment into a number of elements, and assign a reasonable number of personnel to complete the task in an allotted time interval. By carefully monitoring the schedule it is possible to determine variations from predicted effort. A large number of similar studies on related work will develop useful statistical evidence for predicting future requirements. This technique is employed in the prediction of manpower requirements for aircraft production.

Prediction of Development Effort

"Any method of prediction of development effort must be based on a clear understanding of the development goal to be reached and the point at which development work is started. Any new method of prediction must be an improvement over the individual's ability to use his experience in visualizing the required procedures. There are two fairly obvious possibilities for such improvement. These are:

(1) The analysis and evaluation of more pertinent development data than the individuals working on the job normally possess, and

(2) The discovery of significant relationships between the several elements of of the development process.

"Substantial improvement in the accuracy of development time and effort predictions must be based on a comprehensive program of data collection and evaluation. This approach should not be confused with the simple process of utilizing statistical averages, but is rather an engineering investigation of developmental problems in which statistics are one of the obvious tools."(6)

The prime objective of industrial research management is the goal of successful accomplishment. A vital factor to this end is the proper selection and direction of people without which any organization chart is meaningless. The blending of diverse backgrounds and interests into a group where each member can maximize his contributions is then a major task of the research director.

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Alternator drives for jet bombers

Thompson quality control measures aimed to extend reliability levels to a new high

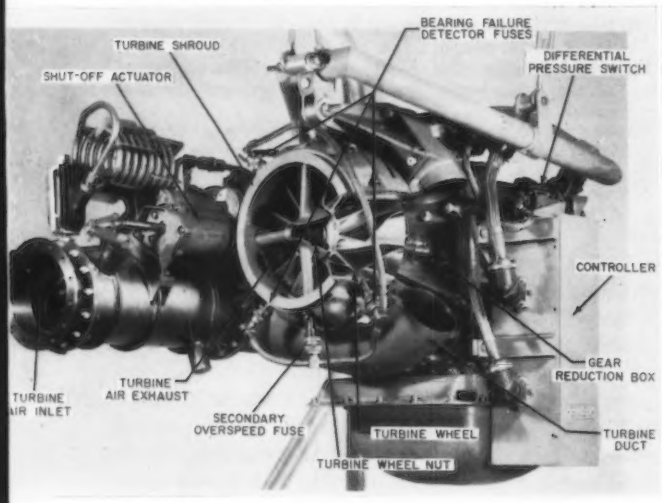
The ever-increasing electric-power requirements on current jet bombers are being satisfied by air-driven, or mechanically-coupled alternator systems. Obviously these systems must be highly reliable, and capable of top performance under the most severe environmental and operating conditions.

The unit developed for this purpose by Thompson Products is an air-turbine-driven, isochronous type, with a fixed frequency of 400 ± 0.9 cps. Already several hundred such units have been produced with only minor component problems.

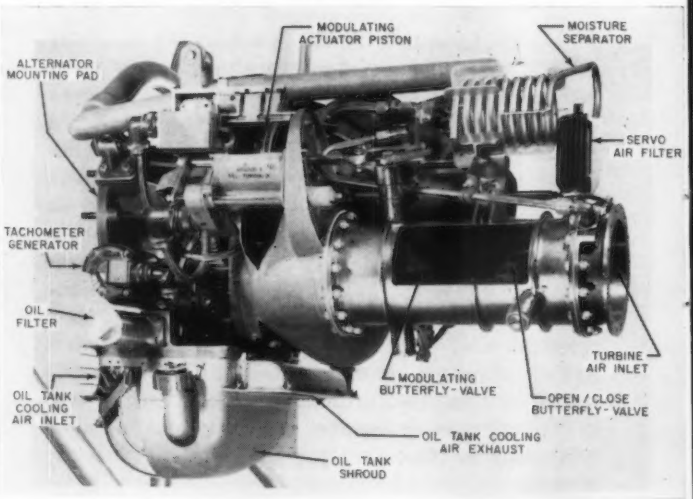
The largest bombers use four of these units, in which case any two must be capable of handling the entire electrical load. Furthermore, if all but one of these units are disabled, the remaining unit must provide full power for all major functions of the aircraft. Actually, four of these units could provide complete electric power for a small city.

Hundreds of parts are required for as-

Alternator-drive cutaway showing turbine wheel installation.



Lateral view of alternator-drive cutaway showing turbine air inlet and butterfly valves.



sembly of one of these units, and each part must meet stringent specifications in order to promote the high level of operational reliability required of the overall system. The requisite reliability is insured through rigid quality-control methods governing both the in-plant produced components, as well as those furnished by outside sources. These oil-lubricated alternator drives, nicknamed OLAD, have successfully completed over 500 hr on test aircraft. They are also accumulating service hours on production aircraft operating in the Strategic Air Command heavy-bomber groups.

Work on the alternator drive was started about five years ago. Thompson was furnished a set of performance specifications, and mating and mounting dimensions. Thompson's Accessories Division developed the mechanical configuration. The control system was developed through the coordination of staff Research and Development, the Electronics Division, and the Pneumatics Development Group.

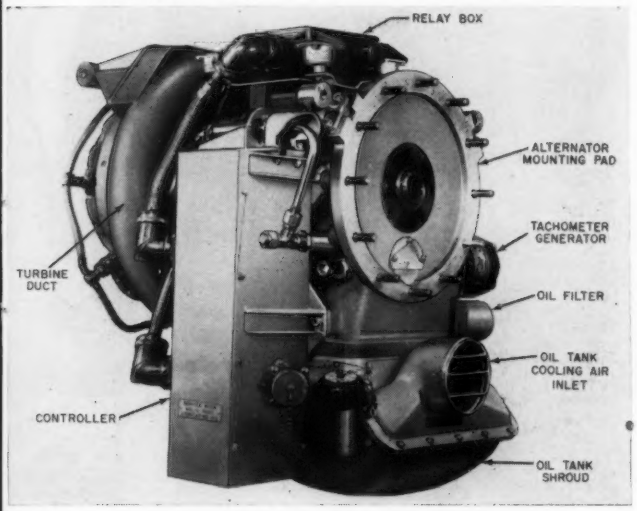
Requirements

Naturally in aircraft design, weight and space considerations are paramount, and the alternator-drive units had to be as compact and light as strength-to-weight ratios and manufacturing processes permitted. In flight, the operational load can fluctuate rapidly, yet the alternator is required to produce a constant frequency, regardless of variations in load, temperature, altitude or air pressure. In addition, since these units are driven by hot gasses derived from the engine compressor-stage, protection must be provided against corrosion, dust, and other contamination.

Synchronization is a critical requirement, as all units on a plane must operate at the same frequency, and any variations must be quickly and automatically compensated. In addition, military specifications require the drives to function for brief periods without their normal oil lubrication.

In case of failure, a unit must cut out without interference to the operation of the plane, or the remaining units. The Thompson alternator drives are designed to meet this requirement.

View of alternator-drive assembly from alternator mounting end.



Mechanical Elements

One of the most important components of the alternator drive is the turbine wheel. Under maximum engine rpm conditions, air-pressure at the turbine wheel is approximately 205 psi, at a temperature of 700 ± 25°F. Under engine idling conditions, when the air pressure is only 10 psi, the turbine wheel is required to maintain 25,000 rpm in order to satisfy the minimum torque requirements for the alternator. The wheel itself was required to combine high tensile-strength combined with light weight; in addition, it had to resist the corrosive effect of high-temperature gases.

To meet space requirements, a titanium, scroll-type wheel was designed with a blade configuration shown in the accompanying illustration.

Through gear-reduction, the 25000-rpm speed at the turbine-wheel shaft is reduced to 6000 rpm to drive the alternator proper. To provide bearing lubrication for the turbine-wheel shaft a jet of oil is continuously fed into the bearings between the races. This means the bearings cannot be shielded. To prevent any oil from passing into the alternator, the output drive-shaft has a spring-loaded carbon seal behind it.

An over-running clutch, connected by a splined coupling to the alternator drive-shaft, precludes the alternator from being converted into a motor.

Controls

Incoming air must be closely regulated to insure a steady volume. Rapid and accurate modulation of airflow is required, since speed, temperature, and altitude can cause considerable variation. The double butterfly-valve system was developed for this purpose. During operation, the outer valve remains either full-open or full-closed. In the event of failure or other difficulty, the shut-off actuator immediately closes the outer valve, cutting off the air supply completely and putting the malfunctioning unit out of action.

The inner valve is under automatic control of the modulating actuator, which receives its signal from the main controller. A tachometer-generator senses speed changes, and supplies the electrical power for controller operation, making the drive independent of the aircraft main electrical system. A load transformer, on one phase

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Alternator drives for jet bombers continued

of the alternator output, senses and gives a signal to correct load variations.

An overspeed detector switch is connected to the shut-off actuator. If the alternator drive develops more than required speed, the actuator closes the outer butterfly-valve.

Air temperature at the intake nozzle is about 700°F, but drops to about 350 to 375°F at the turbine-wheel exit.

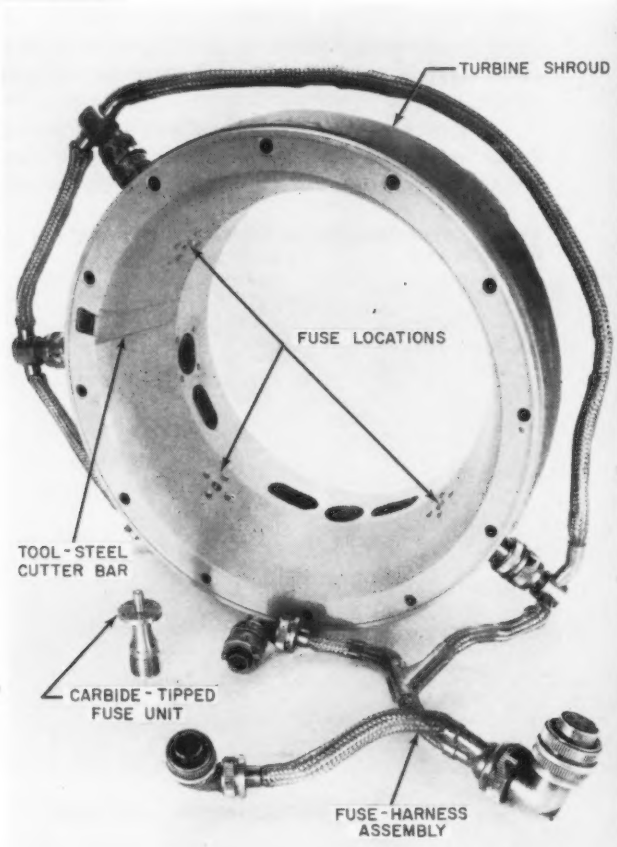
In addition to the over-running clutch and the overspeed detector switch, three other fail-safe features are provided: a fuse operated by the turbine-wheel nut; three fuses, spaced 120 deg apart in the turbine-wheel shroud; and a cutter bar buried flush also in the turbine-wheel shroud.

The fuses are carbide tipped and mounted in the turbine-wheel shroud, with a clearance of 0.015 in. between them and the wheel. Breaking any of these four tips will break or short the electrical circuit, and cause immediate closing of the outer intake-valve. Should the turbine-wheel overspeed, at 35,000 rpm, the plunger in the turbine-wheel nut is driven out to break the fuse. Wobble of the turbine wheel will also break the fuses in the shroud.

Dust and dirt produced a problem with these fuses. At first, ceramic tips were tried. These were blasted off cleanly by the abrasive action of the dust in the airstream, exposing the wires and shutting down the unit. After some research and testing, carbide tips were specified, and there has been no further difficulty of this nature.

A tool-steel cutter bar is also incorporated

Turbine-wheel nut shown disassembled.



Turbine-wheel shroud reveals fusing installation and steel cutter-bar.

as a last-resort destructive measure. If by some unforeseen combination of circumstances, all other controls should fail, and the drive should overspeed, causing bearing failure and producing wheel wobble, the turbine blades would be destroyed by the cutter bar and would permit air to bypass till the unit ran down to a stop.

Suppliers played an important part, both in the original development of the drive, and in effecting continual improvements. The overall concept of the alternator-drive unit incorporates standard components but changes were often made to meet more stringent specification requirements.

Quality Control of Purchased Items

The Pneumatics Division keeps tight control over quality through its control of vendor design and its elaborate testing program. Upon checking of vendor specifications, a limited number of components are ordered. When these arrive they are tested on the drive for qualification. Along with the parts, the vendor submits process sheets detailing the method of manufacture.

If the parts prove out, that vendor design is controlled by issuing a specification drawing, giving all details. No change is permitted in materials, processing, assembly, design, etc., without notification and receipt of written approval.

Naturally, suppliers are continually trying to improve their products and reduce costs. When suppliers want to make a change to effect improvement they merely submit samples and a new process sheet. The parts are then tested

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Control room for test cells where complete alternator drive units are subjected to operational tests.

Alternator drives for jet bombers

continued

completely, both as components and on a drive unit. If results indicate equal or superior performance, approval may be given.

Whenever a part proves defective in testing, it can be traced back to a supplier, and in some cases, back to the point where a change in processing was introduced. Definite corrective action is required before the part can again be put on the acceptable list.

Unit Logbooks

A complete record of each alternator drive unit is kept in its logbook. This contains the entire history of the unit, from design through testing, including information on production of each part.

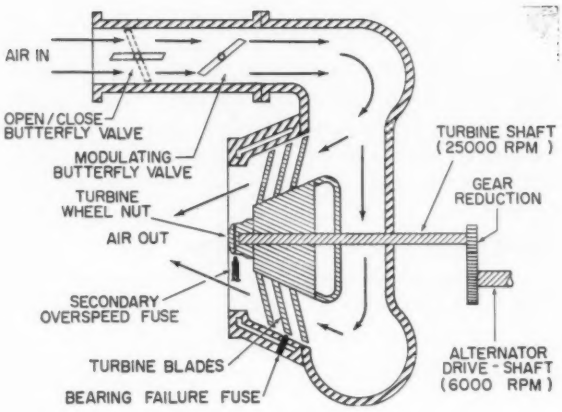
Testing

In addition to standard items of test equipment, some thirty specially-made test stands are required to check out all the components of the drive. For example, the turbine-wheel nut is a relatively simple component, yet it requires two test stands—one to check whether the plunger will trip out at 35,000 rpm, and another to balance it. The Quality Control section is responsible for test-stand accuracy. The development engineers write the specifications for the drive. Another engineering group then writes the specifications for the test equipment.

Turbine Wheel Nut

This relatively simple item furnishes a good example of component design and development on the drive. As stated above, its function is to break a fuse if the drive exceeds 35,000 rpm. Its design presented no problems. It is a hex nut, bored for plunger and locking pin, and internally threaded. At 35,000 rpm, ±500 rpm, the plunger thrusts out to break off the fuse tip.

The nut must be precisely balanced, and the plunger spring must provide the exact amount of loading required to assist the trip-out by centrifugal force. These springs are of quality spring steel, since they must retain their resiliency and not take a set. Shims are used between the spring and the plunger to adjust slight variances in loading.



Turbine-wheel configuration.

Manufacturing

The manufacturing department has various subassembly areas where components are built in advance. They are then returned to the stockroom, along with their billed records, ready for callout as required.

Assembly of the drive units is a station-to-station process. Tests and adjustments are made through progressive phases of assembly. However, when final adjustments are made, these are spot-sealed to prevent tampering.

When assembly has been completed, the unit goes to the testing department for complete unit testing. Further adjustments are made as required, and again spot-sealed.

After final finishing, such as painting, wiring, etc., has been performed, the unit is turned over to the Navy inspector. He reviews the log of the alternator-drive unit, which gives him the complete story.

The alternator drive units are then packaged in metal containers for shipment.

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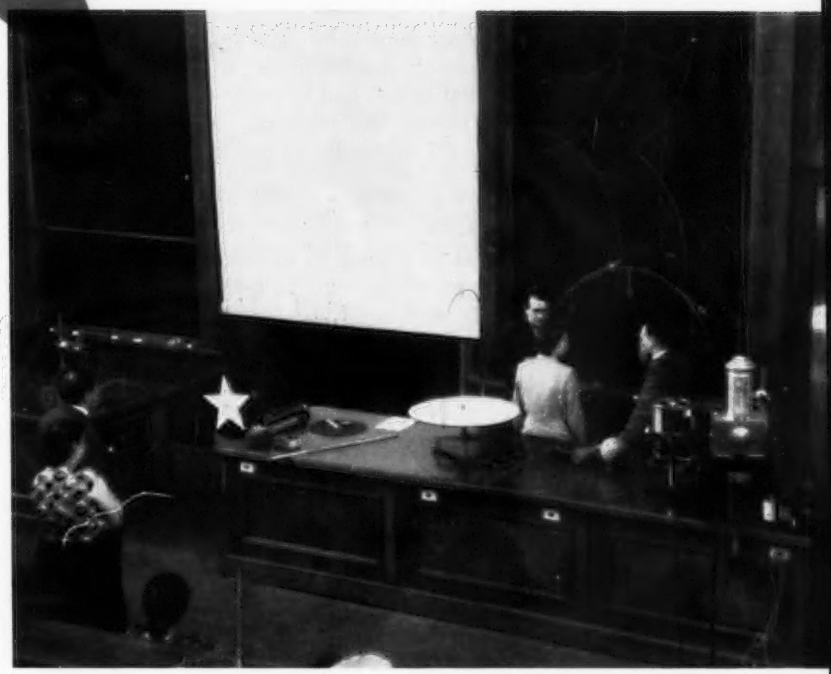
science and engineering education in the USSR

meticulous long-range planning is aimed to stimulate and sustain scientific interest from grass roots up

by Richard E. Stockwell



Lecture room of the physics faculty at Moscow University.

Little is left to chance in Russia. Almost everything is planned down to the smallest detail. One exception is human genetics, which has defied planning everywhere. But since the Soviets cannot plan the production of their geniuses and technologists, they do the next best thing: they seek out the brightest, most able and willing, to bring them into the orbit of the state's interest.

Not long after they swept into power in 1917, the Communists began to channel the country's most talented youth into those fields for which the country had the greatest need, according to the Communist plan. Communism always has had a deep respect for science and technology, and so it was only natural that the Ministry of Education should emphasize training for these fields.

Five-Year Plan Adoption

In 1928, Russia adopted its first Five-Year Plan, and though efforts to mold education to state purposes already were strong, they became much stronger from that date forward. The country needed engineers and technicians of all kinds for the new industry that was being built. By the time the first Plan was completed in 1932, enrollment in elementary schools had more than doubled. Within a dozen more years the figure had nearly tripled (Fig. 1).

continued on next page

education in the USSR continued

Then came World War II, and soon the Germans had overrun the more populated parts of the USSR. Not until 1943 did the Russians begin to gain back these areas, and until then school enrollments dipped sharply. However, following the battle of Stalingrad, elementary school enrollments began to pick up slowly, and today they appear to be leveling off at about 30-million students in their primary and secondary schools. This compares to about 33-million in U. S. grade and high schools.

There have been many glowing accounts of Russia's educational system, especially since Sputnik I. Actually, it has many shortcomings, some arising from the fact that it has had to grow too rapidly and unevenly across the country. The quality of teaching falls off markedly as one gets into the hinterlands.

Meeting Changing Needs

Right now Russia is trying to extend its elementary schooling from seven years to ten and is expanding university and institute facilities, which now turn away thousands of students each year. Some even wait two or three years to gain admission to the universities.

In the ten-year elementary school, which more or less matches the grade and high school training period in the U. S., there is a very heavy emphasis on science and mathematics. Soviet and a typical U. S. grade school curricula are compared in Fig. 2.

As the chart shows, the Soviet picture has been changing. In 1930, some 54 per cent of a Russian student's classroom-time was spent on general education, and 40 per cent on science and mathematics. However, by 1955 this had changed, and general education was down to 47 per cent while science and mathematics took 50 per cent of his time.

At the same time in the U. S. in 1955, about 68 per cent of a student's time went into general education, including courses in domestic science for boys, how to drive an automobile, and many other "soft" subjects. Only 21 per cent of a typical student's time went into science and mathematics. Another 11 per cent went to "other" courses that sometimes even included dancing.

Emphasis on Science

There is no comparison to be found in the U. S. for the science and mathematics taught in

Fig. 3

Soviet schools between the first and tenth grades. The Russian student takes mathematics every year and is into calculus by the time he graduates. He also studies physics for five years, biology for another five, chemistry for four, and one year of astronomy.

Surrounded by this kind of intellectual staple, plus the public adulation accorded the scientist and engineer, it is only natural that many Soviet youths wish to follow a career in science and engineering.

From 1928 to 1954, Soviet higher-education institutions (except for a deep dip during World War II) turned out more teachers than anything else in an effort to build up teaching staffs for the country. Engineers ranked second, with doctors and nurses and other medical specialists following in third place. Graduates in sociological-economic subjects were last, as shown in Fig. 3.

Statistical Comparison

How the U. S. and USSR compare in the number of graduates in different fields is shown in Fig. 4 for the year 1954. Clearly the USSR led in engineering, agricultural and educational graduates, but lagged in health and medicine and fell far behind in sociological subjects and economics.

Fig. 5

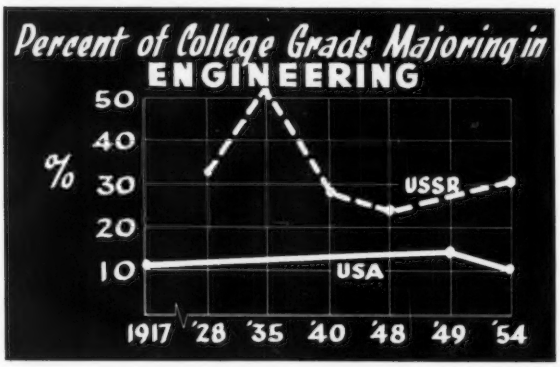


Fig. 2

PERCENT ALLOCATION....
CLASS INSTRUCTION TIME

GROUP of SUBJECTS	USSR GRADES 1-10 1930	USSR GRADES 1-10 1955	USA GRADES 1-12 1955
GENERAL EDUCATION	54	47	67.8
SCIENCE & MATH	40	50*	20.8
OTHER	6	3	11.4

*INCLUDES: 1 YR. ASTRONOMY, 5 YRS. PHYSICS, 10 YRS. MATH, 4 YRS. CHEMISTRY, 5 YRS. BIOLOGY

In engineering graduates, the USSR has maintained a steady lead over the U. S. since 1928, with the peak reached in 1935 (See Fig. 5). The second World War caused slight drop-off in engineering graduates, with some recouping since.

The United States, on the other hand, hasn't had since 1917 as high as 20 per cent of its college graduates majoring in engineering subjects, a percentage the Russians always have exceeded since sometime prior to 1928. In the U. S. the number of engineering graduates reached a minor peak in 1949, fell off again by 1954, and since then has risen slightly (not shown in graph).

Mass-Education Difficulties

The great mass of the Russian people are still peasants, on the state and collective farms, living a little less well than their ancestors. They remain stolid and somewhat indifferent to the changes their country is undergoing. They get enough food (but not a balanced diet), have a roof over their heads, and enough clothing to keep warm (but not dressy), and perhaps have a television set. They are not greatly interested in advancing their lot beyond these essentials, and it has been a problem for the Soviet government to induce them or their children to seek a place in the new industrial society. The Government in the USSR has had to do a lot of sociological pump-priming to get people to want to aspire to industrial jobs and an income in money instead of largely in produce.

The problem of getting this vast, inert, agrarian mass into the educational system, and inspiring it to want to exceed its parents' way of life has been also a part of the same problem. Yet, it is to the offspring of the peasants, if only because they are by far the greater number, that the USSR must look for its greatest number of trainees in science and engineering. Peasant-originated talent, even though it has not been inspired to the nation's new goals, cannot be overlooked. Because of the time-lag from past attitudes to the new Communist-forging-ahead-industrially-and-technologically idea, the Soviet professional labor force has not grown as rapidly as might be expected. It still lags far behind the U. S., though years of intensive effort are now beginning to pay off.

Rising Professional Man-power

The professional labor-force in Russia today is about half the size of that of the United States. About two million people (Fig. 6) constituted the USSR's professional labor force in 1955, compared to over five million in the U. S. in 1950. However, the Russian rate of training professional people has been rising as we have

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education in the USSR continued

Fig. 1

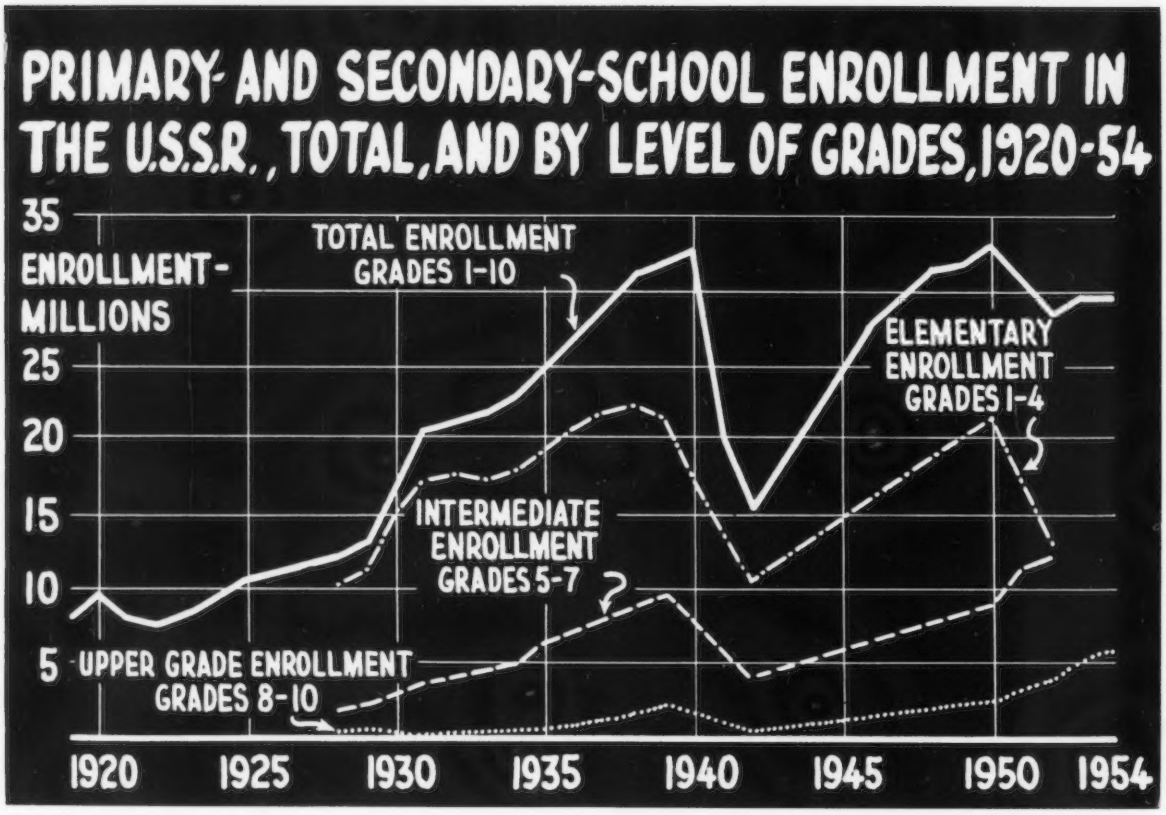


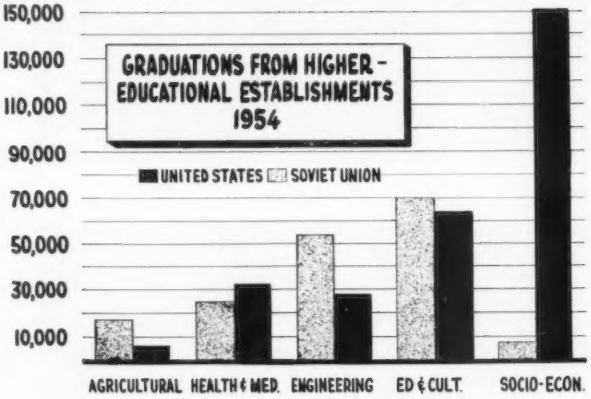
Fig. 7

MECHANICAL ENGINEERING CURRICULUM

	U.S.S.R.
YEARS	5*
POLITICAL HUMANITIES & SOC. SC.	377
GENERAL SC. (PHYSICS, CHEMISTRY, CALCULUS, DRAWING, MECHANICS)	1456
GEN. ENGRG. (STRENGTH OF MAT. FLUID M., MACH. DES, THERMO., E.E.)	1407
SPEC. ENGRG. (PROCESSES, STRUCTURES, MACHINE TOOLS)	1286
OTHER (MIL. TRG 404)	528
TOTAL	5054

* INCLUDES SIX MONTHS THESIS (DIPLOMA) PROJECT

Fig. 4



seen, and today it is about twice that of the U. S. In time, if the relative rates of the two countries do not change, the USSR will surpass the U. S. in professionally-trained people, particularly in science and engineering, which have received more emphasis in the USSR.

From the time they are in the third and fourth grades, the Soviet youth are watched for their talents and interests. These are correlated with Russia's most pressing needs.

Directing Youth Activities

In every city there is a Young Pioneer Hall or Palace, where youths from nine to 14 take part in a wide variety of extra-curricular activities, including sports, but mostly to teach them how to build and test airplane models, how to shoot, to row and sail, to take care of themselves out of doors, to solve simple navigational problems, and build and operate simple radio sets. This has been going on intensively in Russia to the writer's certain knowledge since sometime during World War II.

Then, when the Soviet youth is 14 years of age he can enter DOSAAF, the All Union Society for the Support of the Armed Forces. At this stage the training program is extended, and becomes serious. Here Soviet youth may learn to fly a glider or a powered airplane, tear down motors and put them together again, work out problems in chemistry, etc.

These extra-curricular activities, supplementing the intensive classroom work in science, and the social pressure to go into scientific and engineering subjects serves to direct and lead the young people of the USSR. By the time they have completed ten years of elementary training, plus the Young Pioneers and DOSAAF, they can enter college, if they have the aptitude.

Discrimination of Talent

Today in Russia the number of youths who wish to go to college exceeds the facilities, and entrance examinations are highly competitive.

Last summer, on a visit to Russia, I was given a half-day tour of Moscow University's Physics Faculty. Students who wished to take this five-year course at this admittedly superior school had first to pass a severe entrance examination (unless they were honor students certified as to their abilities by the elementary school). Fully 70 per cent of those seeking to get into the Physics Faculty at Moscow University, I was told, failed to pass their entrance examinations. This is indicative of the keen competition practiced in picking the future physicists of Russia. While the standards for selecting engineers are not as stringent, they are still high, and hereafter it will not be easy to win the Lenin Prize for contribution to aviation (with 150,000 tax-free rubles) without really knowing and contributing.

Gradations of Higher Education

There is a whole system of higher education in the USSR to take care of the different levels of student interest and capability. Many of these institutes engage in teaching various kinds of engineering, and several are devoted exclusively to training people for the aviation industry in all of its aspects in the USSR.

The Zhukowsky Air Engineering Academy in Moscow is the top-ranking educational institution for aeronautical engineers. This was the academy visited by Gen. Nathan Twining when he went to Russia in 1956. It has a stiff, five-year course for about 2500 students (five hundred new admissions each year). Graduates become second lieutenants in the EAS or engineering services of the Soviet air forces. Key positions are available to such graduates in the air forces, in Aeroflot, and the Ministry of Aircraft Production.

In addition, a number of other specialized institutes, having to do with aeronautics, are scattered around the country and admit promising youths. One such institute, in Moscow, is called the Ordzhonikidze Aeronautical Institute, which trains engine and airframe mechanics in large numbers. The Moscow Aircraft Institute or MAI, run by the Ministry of Aircraft Production, trains students in aircraft production techniques. Kharkov's Aeronautical Institute specializes in training students who wish to work in the airframe or engine industry. There is a similar institute at Kuibyshev, long an important engine-production center in the USSR. Other aviation institutes are known to exist at Irkutsk and Kazan, and probably at other places as well. At Ufa there is an aeronautical institute concerned with training engineers for powerplant design, and in Leningrad there is training in component items for aircraft, as well as training in electronics. A Riga institute trains personnel in aircraft maintenance.

Cooperative Programs Stressed

Unlike higher education in the U. S., there is a great deal of cooperation between and among the academic institutions, the industry, and the top design bureaus. For example, the Central Aerodynamics and Hydrodynamics Institute (TsAGI) sometimes said to be like our NACA, actually performs a much broader service for the USSR. Advanced students from some of the institutes, particularly in the Moscow area, spend much of their time during their last year or two

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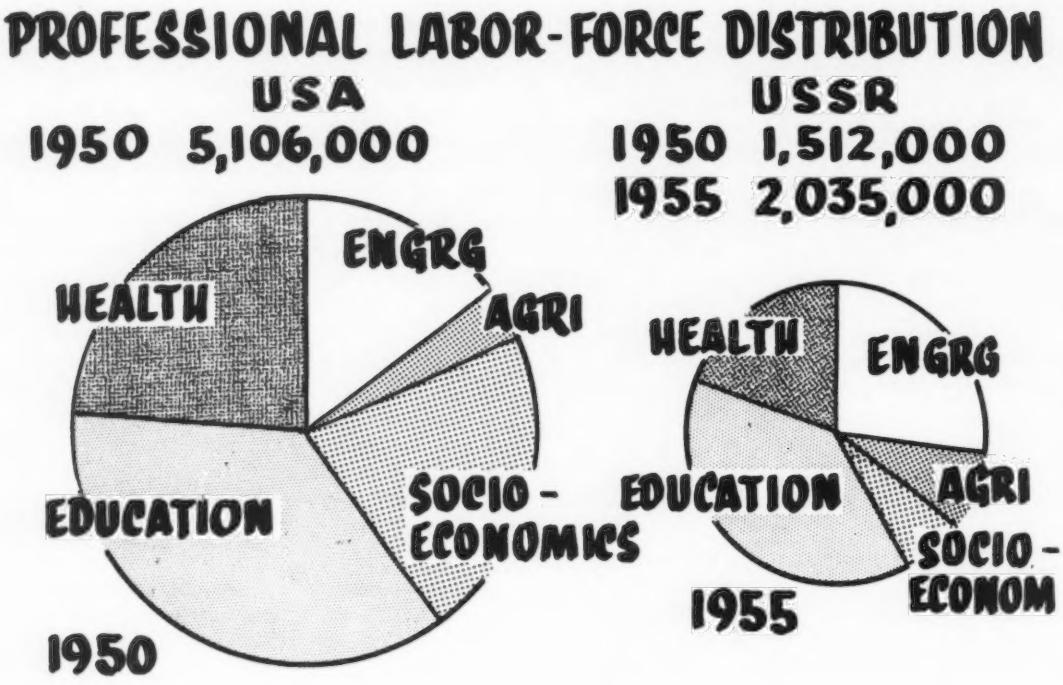
education in the USSR continued

Fig. 6



of training at TsAGI. Here they carry out detailed, practical work which they then must defend before their superiors, who may include professors who are on the staff of TsAGI as well as the Zhukowsky Air Academy, and may even be associated with a design bureau, or the Ministry of Aircraft Production.

Mechanical Engineering Curriculum

Mechanical engineering in Russia is a five-year course, and it is interesting to note that the student in that country spends over 5000 hours of classroom-time in completing his course, and that he must undertake a special thesis or diploma paper of his own (Fig. 7).

Of the 5054 hours of study, the Russian mechanical engineer will devote only 377 to political subjects, the humanities and social science. His general science training in physics, chemistry, drawing, fundamentals of mechanics and so on will run to 1456 hours. General engineering studies, including the strength of materials, fluid mechanics, machine design, thermodynamics and electrical engineering training in his last two years, including studies of industrial processes, structures, machine tools, and so on, adding up to another 1286 hours.

Finally, he will have 404 hours of military training and 124 hours of other subjects. During his final year he will be assigned to a specific project, perhaps at some industrial plant, where he works under the engineering staff. Or, if he is exceptionally lucky he might do his work at AsAGI.

Once he has finished this and passed his oral and written examinations, he is assured of a job, though its location will be determined in large measure by the Ministry of Higher Education. He will be well paid in his new position, and may find himself launched on a road that leads to a plant directorship.

He has before him the prospect of becoming a national hero, like Andrei Tupolev, doyen of Russia's designers. He may win great prizes, as well as receive from the state a free house, a car, and other emoluments. In Russia they believe in finding their geniuses at an early age, of directing them to the state's needs in keeping with their abilities, and then of rewarding them handsomely.

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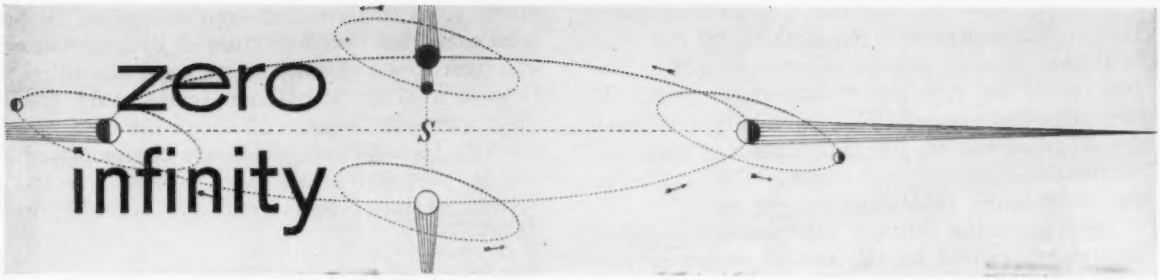
Richard E. Stockwell is author of Soviet Air Power. In 1957, to visit Russia, he took a leave of absence from the General Electric Company's Aircraft Gas Turbine Division, where he is management information analyst.

The statistics presented in this article are based on the author's private research and "Soviet Professional Manpower" by Nicolas DeWitt, published by the National Science Foundation.



This department is created to encourage thinking in new dimensions; thinking that is free of the often constraining influence of immediate difficulties. Technological progress is to a great extent based on departures from the conventional or the status quo. That which is considered illogical or impossible to accomplish, has and always will be so only within the limited compass of accumulated knowledge up to a particular date. Speculative thinking is man's most precious asset. It is hoped that this department will provide an outlet for such thinking and will serve to stimulate further ideas. The implications of the symbolism for this department head are that: while the immediate worth of a concept may range from nil to infinity, its true value will only be determined in the ultimate.

ramifications of the rocket

Meyer M. Markowitz chemist, Foote Mineral Co.

Orbiting satellites proclaim the non-earthly use of rockets. The earthly uses promise to be no less spectacular. Rocketry is a derivative science and as such depends upon the knowledge and skills of the whole gamut of the basic and applied studies. As a result of this diversity of interest, many direct and peripheral benefits have been and will be derived from rocket research.

With the accent on the military and intergalactic aspects of rocketry, its more down-to-earth features are at present obscured.

Propellants

The performance of a rocket is intimately connected with the energy-producing capacity of its propellants; therefore, rocket development has hinged to a great extent upon finding new combinations of chemicals to yield a higher energy output per unit weight and per unit volume of propellant mixture. This search has resulted in both the accumulation of knowledge and of know-how in the manufacture, handling, storage, and use of a wide variety of chemicals heretofore regarded as untouchable. These chemicals are far more diverse in nature than the customary hydrocarbon fuels and airborne oxygen.

The term "combustion" embraces a much broader field of interaction including such "oxidizing" agents as highly concentrated hydrogen peroxide (H_2O_2), nitric acid (HNO_3), fluorine (F_2) derivatives such as chlorine trifluoride (ClF_3) and perchloryl fluoride (ClO_3F), ozone (O_3), and solid salts of perchloric acid ($HClO_4$). The realm of fuels no longer covers only naturally-occurring organic compounds but also materials like hydrazine (N_2H_4) and unsymmetrical dimethylhydrazine ($(CH_3)_2NNH_2$, the boron hydrides like pentaborane (B_5H_9) and decaborane ($B_{10}H_{14}$), various rubbers and polymers, and light metals including lithium (Li), beryllium (Be), magnesium (Mg), aluminum (Al), and their derivatives. In addition, we also find materials, called "monopropellants," which are capable of yielding considerable amounts of energy through self-decomposition (like acetylene (C_2H_2), the previously mentioned hydrazine (N_2H_4) and hydrogen peroxide [H_2O_2]), and through self-oxidation reactions (like nitromethane (CH_3NO_2), ethylene oxide (C_2H_4O), and ($C_3H_7NO_3$) propyl nitrate).

Often the energy-producing capacity of a particular fuel, oxidizer, or monopropellant is reflected in adverse stability characteristics and handling problems.

A classic example of a continuously decomposing material, now an article of commerce, is highly concentrated hydrogen peroxide (90 per cent H_2O_2 and up). Thermodynamics tells us that hydrogen peroxide will eventually decompose to form water and gaseous oxygen with the evolution of about 1200 BTU per pound of material—a quantity of heat sufficient to raise the temperature of the decomposition products of 100 per cent H_2O_2 to about 1000° C. However, only kinetics can tell us those factors of importance in determining the rate or speed at which this decomposition will occur.

Painstaking studies have shown that the stability of concentrated hydrogen peroxide is strongly dependent upon its purity. This requires the absence of trace amounts (expressed as parts per million) of dissolved metals such as iron, nickel, chromium, manganese, and copper, and of organic, oxidizeable adulterants. By careful man-

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ufacturing, handling, and use of stabilizing additives (sodium stannate (Na_2SnO_3)), 90 per cent hydrogen peroxide can be maintained with but a few tenths per cent decomposition per year. Illustrative of the specialized techniques developed for this chemical are the pure aluminum shipping drums (99.6 per cent and better) with vent holes for the steadily emanating oxygen gas.

Tempering through experience, the initial excitement caused by the use of rocket propellants has led to many unique non-propulsive applications. Thus, 90 per cent hydrogen peroxide finds use as a polymerization catalyst, and as a major reactant in various syntheses. Hydrazine is very effective in alleviating and in preventing iron oxide (Fe_2O_3) in hot water boiler systems. Chlorine trifluoride has been incorporated in an oil-well tool where the fluorine-like reactivity of the compound can easily sever a length of pipe. The entire chemistry of boron has been revolutionized through the rocket program. Not only do we have rocket and jet fuels based on the boron hydrides but also a number of valuable by-products. Among these compounds are boron carbide (B_4C) which is comparable to the diamond in hardness, and boron nitride (BN) which displays unusually good lubricating properties at high temperatures.

Super Propellants

The top level of performance to be expected from the class of propellants we have been discussing is, on the usual basis of specific impulse, (thrust-per-pound-per-second of propellant mixture) about 400 sec. A system such as liquid hydrogen-liquid fluorine can yield a specific impulse of about 370 sec at an expansion ratio of 20 and a reaction temperature of about 4500° C.

An approach to higher specific impulses may be made by the use of free radicals. These substances are materials characterized by the presence of a free-bonding electron in the outer shell of electrons of one of its constituent atoms. Such an electronic configuration generally puts the substance in a state of high potential energy. This energy is realized when two free electrons combine to give a stable electron pair. Among the free radicals capable of giving much improved performance is the hydrogen atom (H). Early utilization of the energy released by the recombination of hydrogen atoms was made in the "atomic-hydrogen torch" welder. In this device, developed by Irving Langmuir, a stream of hydrogen atoms is formed by passing hydrogen molecules through an electric arc. The gas is then allowed to impinge upon the metal surface to be joined where the recombination reaction $2H \rightarrow H_2$ occurs with the liberation of sufficient heat to weld the metals together. Some 93,000 BTU are released when one pound of hydrogen atoms react to form hydrogen molecules. It has been computed that a mixture of hydrogen atoms and hydrogen molecules of such a composition as to give a 2700° C reaction temperature should yield a specific impulse of about 750 sec. Other possible free radicals which are contemplated as rocket propellants are such species as imine (NH), methinyl (CH), and the boron hydride (BH).

The Rocket as a Chemical Plant

As the combustion gases of a rocket expand through the nozzle, they achieve a high velocity and a corresponding lowering of temperature. It has been gaged that the cooling rate in the nozzle of a 1000 lb thrust motor is in the order of 3×10^7 °C per sec. This makes the nozzle portion of the rocket a very effective refrigerator. With such rapid rates of cooling, it becomes possible to "freeze" or to "quench" the composition of the gases as they pass from the higher to the lower temperature.

There are some chemical species which are thermodynamically unstable at low temperatures, but which are capable of existence at high temperatures. Accordingly, with the rocket we have a means of preparing such substances at high temperatures in the combustion chamber as well as a means for cooling these chemicals to more moderate temperatures by expansion through the nozzles. At the lower temperatures, the rates of decomposition of such materials will be so lessened that we can use them before appreciable decomposition occurs.

An example of the possibilities inherent in the rocket as a chemical plant is the manufacture of nitric oxide (NO), used in the manufacture of nitric acid (HNO_3). Calculations by Farrington Daniels have shown that at 2100° C, air has an equilibrium concentration of 2.4 per cent nitric oxide from the reaction of atmospheric nitrogen (N_2) and oxygen (O_2). Unless the gas mixture is cooled to about 1500° C at the rate of about 20,000° C per sec, all the nitric oxide will revert back to its constituents.

Experimental studies by Paul Winternitz indicate that about 1000 lb of NO per day could be produced by cooling the combustion gases (at 2700° C) from oxygen enriched air and ethane in a 2000 lb thrust rocket.

Because propellants can provide high-temperature, high-pressure gases, they represent a convenient source of heat energy which can be converted to work. In this regard the small (total weight 0.60 lb) solid propellant rocket designed for spin stabilization and separation of the third stage of the Vanguard vehicle may prove of value. The small rocket can be used to activate switching and safety mechanisms.

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DESIGN

Redstone.

Flight, (May 23, 1958), 4 pp. A review of its development and design features, supplemented by detail cut-away drawing.

Progress Report on the Brantly B-2 Helicopter.

F. A. ERICKSON. *AHS News Ltr.,* (May 1958), 7 pp. Development and certain design features are presented.

Designer's Guide to Honeycomb-Sandwich Structures.

A. MARSHALL. *Mach Des.,* (May 15, 1958), 10 pp. Characteristics, applications and manufacturing techniques are presented.

"Aerodynamic" Combustion Ups Afterburner Performance.

J. BERTIN and B. SALMON. *Av. Age,* (May 1958), 2 pp+. Study of flame stabilization technique using auxiliary jets instead of flame holders.

Design Trends and Developments in High-Temperature Hydraulic Components.

F. L. MONCHER and L. D. TAYLOR. *Mach Des.,* (May 15, 1958), 3 pp. Properties of high-temperature hydraulic fluids are reviewed, and typical applications are discussed.

Vickers Vanguard.

I. STAMBLER. *Av. Age,* (May 1958), 3 pp. Design features and performance characteristics discussed.

How and When to Specify Tolerances of Form.

F. L. SPALDING. *Mach Des.,* (May 15, 1958), 8 pp. The proper use of tolerances illustrated and discussed for flatness, straightness, twist, parallelism, squareness, angularity, symmetry, roundness, concentricity, alignment, and contours.

General Electric's X-405 Vanguard Engine.

L. MICHELSON. *Missiles and Rockets,* (May 1958), 4 pp. Evolution and design features are discussed.

Punched-Tape Positioning Controls Britain's Newest Wind Tunnel.

D. BARLOW. *Control Eng.,* (April 1958), 5 pp. Design features and automated operation discussed.

D558-111 Study Helped Pave Way for X-15.

I. STAMBLER. *Av. Age.,* (May 1958), 3 pp. Design features and operational requirements of Douglas' D558-111 Mach 9 research plane are reviewed.

Where and How to Use Plain Spherical Bearings.

A. R. MCCLOSKEY. *Mach Des.,* (May 15, 1958), 4 pp. Design characteristics and suggested applications are discussed.

MATERIALS and PROCESSES

Niobium . . . A Prospect for Aviation Gas Turbines.

W. S. HAZELTON. *SAE Journal,* (May 1958), 3 pp. Niobium properties compared with those of other established alloys, for high-temperature use.

Behavior of Reinforced-Plastic Laminates at Extremely High Temperature.

N. B. MILLER and E. L. STROUSS. *Mach Des.,* (May 15, 1958), 1 p. The effect of high temperatures on such laminates are briefly reviewed.

Tooling in Plastics.

Acft. Prod., (May 1958), 3 pp. Molding and laminating techniques with epoxy-resins discussed as practiced at Saunders-Roe LTD.

Developments in Aircraft Turbine Lubricants.

K. L. BERKEY. *SAE paper #47B*, (April 8-11, 1958), 9 pp. Properties of present-day lubricants and requirements for some future ones are reviewed.

New Facts on the Nitriding of 4140 and 4340.

A. J. SCHWARZKOPF. *Iron Age*, (May 29, 1958), 4 pp. Relationship discussed between core hardness and nitrided case hardness characteristics of these two steels.

Skin-Polishing.

R. D. EDWARDS. *Acft. Prod.*, (May 1958), 6 pp. Description given for large-scale chip-abrasion equipment for finishing Vickers Vanguard integral wing-skin panels.

Electromagnetic Test Measures Effects of Shot Peening.

P. M. UNTERWEISER. *Iron Age*, (June 5, 1958), 3 pp. Non-destructive testing application described as practiced in Russia.

PRODUCTION

Contour-Finishing Missile Noses to 2 Micro-Inches.

R. LE GRAND. *Amer. Mach.*, (May 5, 1958), 3 pp. Description of setup and procedure as developed by Avco's Research and Advance Development Div.

High-Temperature Brazing.

J. V. LONG and G. D. CREMER. *Av. Age*, (May 1958), 2pp+. Various applications used at Solar Aircraft Co. are depicted.

Low-Cost Tooling: The Use of Aluminum-Powder Filler Plastics for Moulding Techniques.

Acft Prod., (April 1958), 4 pp. Materials, methods and processes given in the development of machine vise-jaws with steel-inserts for heavy-duty gripping, and for press-form tools, as practiced at Saunders-Roe Ltd.

New Process for Regenerating Copper Etch Baths.

Iron Age, (May 22, 1958), 1 p. Description of process in brief, as developed by Bell Telephone Laboratories, for wiring board applications.

Missile Production Requires New Techniques.

F. R. SWANEY. *Tool Engr.*, (May 1958), 4 pp. Manufacturing problems and solutions reviewed by general superintendent of experimental production at the Chrysler Corp.

The Functions of Guided Missile Checkout Systems.

J. TAMPICO and A. E. RESNIK, *Control Eng.*, (April 1958), 5 pp.
Description of general functions and equipment of automatic test sets used to check out missile systems in the field.

Applications of Numerical Control.

L. S. PECK. *Tool Engr.*, (May 1958), 4 pp. Author answers questions presented by tool engineers interested in applying numerical control to production problems.

X-Ray Will Measure "Blind" Dimensions Accurately.

Iron Age, (May 15, 1958), 3 pp. Description of new technique and its applications.

FUELS

Possibilities and Problems of Some High-Energy Fuels for Aircraft.

W. T. OLSON. *SAE paper #41B*, (April 8-11, 1958), 35 pp. Discussion of factors leading to fuel selection, the chemical possibilities for high energy fuels, and some of the problems attendant to their application to flight propulsion.

The Future of Aircraft Fuels.

R. J. HEASTON. *SAE paper #41A*, (April 8-11, 1958), 7 pp. Development of tailor-made fuels are discussed in terms of specific applications for obtaining major breakthroughs in air-breathing weapon systems. Consideration given to the main physical and chemical properties characterizing future fuels.

BOOKS RECEIVED

Aids to Efficient Machine Design in Welded Steel.

The Lincoln Electric Co., 1958. 96 pp. $1.00. This brochure contains practical information directed primarily to machine designers who wish to utilize welded steel design. Functional illustrations, tables and nomographs are included to facilitate the solution of typical problems.

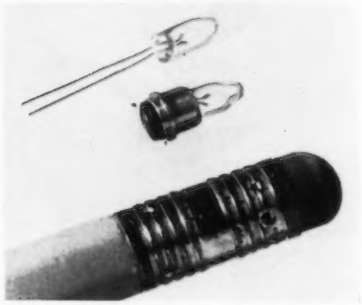
Standards for Physical Security of Industrial and Governmental Facilities.

United States Government Printing Office, 1958. 44 pp. 30¢. "The purpose of this publication is to provide a general framework of physical security protection that can be adapted to meet the varying risks of covert acts in different industries and facilities."

materials / components

Miniature Lamp Bulb Has 60,000 Hour Life

A recently developed subminiature lamp measures ⅛ in. by ¼ in. Life expectancy is 60,000 hr. at 5 v. It is reported as



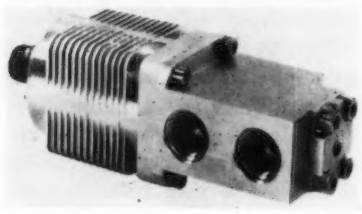
the smallest commercially designed long-life lamp made. Originally designed for integrally lighting aircraft instruments, it is receiving high interest from inspection instrument designers.

Chicago Miniature Lamp Works

Circle 109 on postcard for more data

New Firm Offers Valves For Hydraulics, Pneumatics

A line of high pressure pneumatic and hydraulic valves for aircraft and missiles is capable of controlling such fluids as



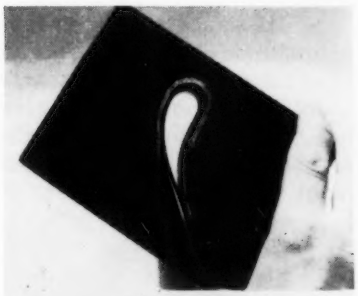
hydrogen peroxide, nitric acid, normal propylinitrate, helium, nitrogen, and liquid oxygen. Currently under production are some 48 different solenoid valves. Piloted and direct acting valves are available from pressure ranges of 0 to 3000.

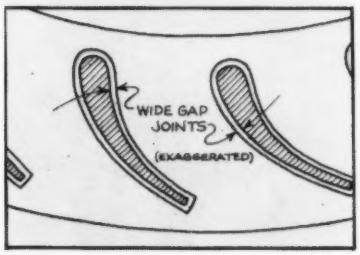
Skyvalve, Inc.

Circle 118 on postcard for more data

Brazing Alloy Suitable For Closing Wide Gaps

A new brazing alloy for high-temperature service, is especially developed for use with





large clearances up to 0.050-in.

Designated W. G. Nicrobraz brazing alloy, the material is recommended for use in non-rotating lightly loaded parts and structural assemblies, that have cross-sectional thicknesses of 1/16 in. or greater. It is well suited for applications where large fillets are desired.

Wall Colmonoy Corp.

Circle 101 on postcard for more data

Fuel Pump Used With Specific Fuel Control

A cartridge-type fuel pump, designed primarily for use as an integral part of a unitized fuel control, was announced by Chandler-Evans division of Pratt & Whitney Co.

Light in weight (2 lb.), and measuring approximately 3 x 2½ in., this dual element gear pump delivers 1000 lb. of fuel per hour at 650 psi, operating at 3600. The company indicates that pumps of the same design could be produced for any

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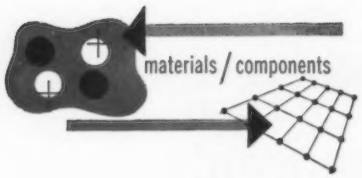


required fuel capacity with corresponding size variations.

Chandler-Evans Div. of Pratt & Whitney Co.

Circle 108 on postcard for more data

Aircraft Vacuum Pump Needs No Lubrication

An aircraft vacuum pump that requires no lubrication and discharges oil-free air is now available.

Designated Model 033612, the unit has been designed as a direct replacement for the Pesco Model 3P194 (or equivalent) vacuum pump.

Because no lubrication is required, oil supply lines, oil separator and attendant pipe, fittings and drains are eliminated. Reductions in installed weight up to 25 per cent are achieved with the new design.

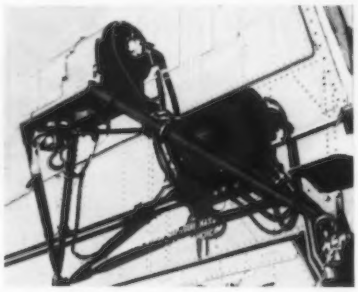
Pesco Products

Circle 116 on postcard for more data

Helicopter Lift Cable Stops Load Rotation

The complete cable assembly made by Bergen has an unusual construction. A stainless steel lifting capable for helicopters is with the strands of the cable wound in opposite directions. The result is a non-rotating cable.

With a non-rotating cable any object being lifted will be subjected only to vertical motion. Spin, or circular motion, about the vertical axis of the cable is thought impossible. This is important when repeated rescues are made and may be a deter-



mining factor in the decision to move the critically wounded.

The assembly, with swaged connections, comes in standard sizes 7/32 to 3/16 in. in diameter and has been tested up to 2000 lb. max. load.

The Breeze Hoist is shown on the Sikorsky S-58 Helicopter. It uses a 600 lb max. cable.

Bergen Wire Rope Co.

Circle 114 on postcard for more data

Adaptable Transducer Has Wide Pressure Range

Designed for use in temperatures up to 300°F, the Model 45176 pressure transducer is adaptable to applications requiring a high output electrical signal proportional to a pressure input.

This unit is available in ranges from 0-5 psi to 0-150 psi (absolute, differential, or gage), with resolution up to 450 wires in the higher resistance ranges. The unit is furnished with one or two precision potentiometer pickoffs, which can conform to any normally desired function.

G. M. Gianni and Co., Inc.

Circle 115 on postcard for more data

High Power Focus Coil

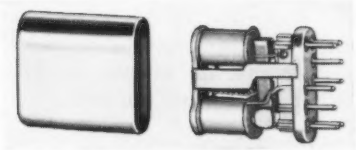
Type F20 electromagnetic focus coil is designed for special purpose 1½ in. neck diam cathode ray tubes requiring short focal lengths at high (up to 25) accelerating potential without overheating.

Minimum spot distortion is assured by machining coil case to close dimensional tolerances. Together with using top quality soft magnetic iron in the case, this results in a uniform focusing field. Sharp focus for high beam currents is assured by the large I.D. to focus gap ratio.

Syntronic Instruments, Inc.

Circle 107 on postcard for more data

Micro-Miniature Relay Weighs Only 0.35 oz.



The hermetically sealed continuous duty Series 1005 micro-miniature Guardian Relay is designed for low level circuitry. It meets all pertinent military specifications.

Compact arrangement is 2 pole, double throw (2 Form C). Contacts carry rating of 3 amp at 125°C per MIL-R-25018 and 2 amp at 125°C per MIL-R-25108 and MIL-R-5757 C; no exceptions.

Unit is completely "vacuum-de-gassed" prior to sealing in nickel-silver can. Measures 0.844 x 0.781 x 0.34 in. Weight hermetically sealed is 0.35 oz.

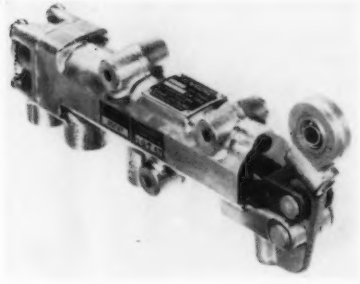
Guardian Electric Mfg. Co.

Circle 111 on postcard for more data

Brake Control Valve Usable In Pneumatic and/or Hydraulic Systems

A new brake valve works equally well in either pneumatic, hydraulic, or combination pneumatic-hydraulic service.

Designed for 3000 psi service, the Model 9904 is a compact, lightweight, precision unit having excellent control characteristics.



The valve has a forged aluminum alloy housing, and an operating temperature range of 65 to 160°F. It weighs only 1¼ lb.

Tactair Valve Div., Aircraft Products Co.

Circle 103 on postcard for more data

Mechanical and Ductile Properties Improved For Mg-Zn-Zr Cast Alloy

A controlled chemistry version of casting magnesium-zinc-zirconium alloy to increase mechanical properties and ductility has been developed.

This alloy has been designated South Gate Excell-51, and meets Federal Specification QQ-M-56. The alloy has been successfully poured in complex design configurations.

Thin wall missile control surfaces and electronic chassis components are typical of items now being produced.

South Gate Aluminum and Magnesium Co.

Circle 100 on postcard for more data

Valves Control Air Mixtures In Jets

A series of Fabrilite valves are available as in-line shut-offs to control the flow of hot, cold or mixed air through air ducts in jet planes.

The valves are fabricated of non-corrosive stainless steel monel or aluminum, made to operate at duct temperatures from minus 65 to 850°F, against pressures from 5 to 225 psi and can operate in ambient temperatures of 450°F.

A specially designed disc and valve seat insures positive opening and closing with a metal to metal sealing surface.

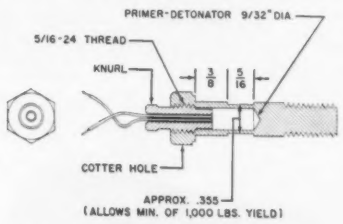
Vap-Air Div., Vapor Heating Corp.

Circle 117 on postcard for more data

Explosive, Bolts Tailored To Specific Application

Custom designed and engineered explosive bolts, and squibs, have excellent control over the area of fracture, minimum shrapnel, and extremely high reliability of function.

The explosive bolts consist essentially of a standard fastener, modified to accommodate an explosive squib. The principal design feature is that the final cross sectional area in tension (or in shear) must be equal to the original area before the explosive component is added. Accordingly, the O.D. of one



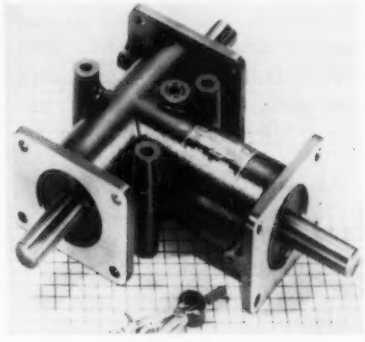
of these units is larger, for the same external load, than the equivalent bolt without the explosive feature.

Beckman and Whitley Inc.

Circle 105 on postcard for more data

Aircraft Line Broadened On Right-Angle Gear Drives

Designed specifically for airborne application, a new right-angle bevel gear unit can be used as an original equipment component or for replacement and repair use. It is available in either 2-way (Model AR-333) or 3-way (Model AR-335) transmission styles and with either 1:1 or 2:1 gear ratios.



Designated ANGLgear, the line includes 12 models ranging from 1/3 to 2¼ horsepower for use in either manual or power-operated transmission systems.

Airborne Accessories Corp.

Circle 104 on postcard for more data

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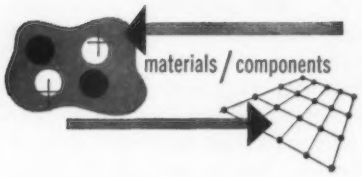


Servo Repeater System Is Self Contained

The Model W 1902 is a self contained servo having a 31/32 in. diam, 4 in. length, and 13 oz. weight. The unit includes a servo amplifier, servo

motor, potentiometer (single or multi-turn), input power step down transformer, and gear train.

The unit positions its output shaft proportional to a 400-cycle input signal voltage in the range of 0-10v or 0-100v (full scale). Typical performance with 200:1 gear ratio is: follow up accuracy, ±0.05 per cent of signal voltage.

The Model 1902 meets MIL-E-5272A and is applicable to aircraft, missile, and ground support system, wherever high performance and miniaturization are an advantage.

Waldorf Instrument Co. Electronics Div.

Circle 113 on postcard for more data

Dual Purpose Unit Serves as Seal, Spring

A small ring that has its primary use as a spring, has a

secondary application as a pressure seal. The controlled spring load is 20 lb ±2, at 0.040 in. deflection. It is operable to 1000°F.

Spring seals have withstood tests of up to 75 million compression cycles without failure. This particular seal is a 5 in. O.D. made for a high temperature application in a jet engine.

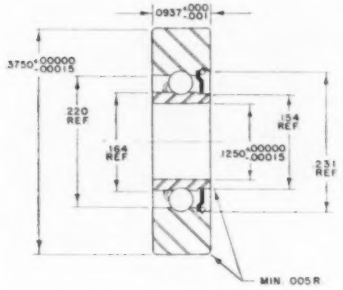
Skinner Seal Co.

Circle 112 on postcard for more data

Wafer Bearings Designed For Synchros, Servos, Motors

A series of "skinny" bearings called Microwafers or "wafer" bearings is custom manufactured for synchros, servos, small motors, potentiometers, and gear trains.

In proportion to their outside diameters, wafer bearings have widths narrower than standard bearings.



These bearings are available in a wide variety of shaft and housing diameters. Available bore diameters range from .0937 to 0.1875 in. Housing diameters are from 0.2500 to 0.4375 in.

New Hampshire Ball Bearings

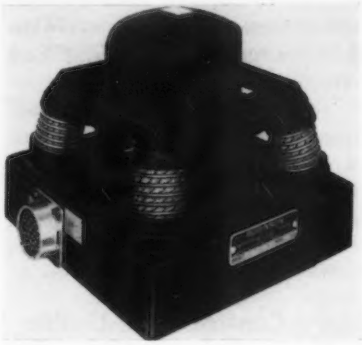
Circle 102 on postcard for more data

Engineered Mounting System Protects Gyroscope

A light-weight standardized mounting system has been designed to protect delicate airborne gyroscopes from destructive shock and vibration in several jet fighter aircraft.

Special features include angled resilient elements which add to stability, reduce space requirements, and contribute to excellent rotational stability characteristics.

With an input acceleration of 10 G, Model 1995 provides 94 per cent vibration isolation in the 200-350 cps fre-



quency range, thereby reducing the equipment environment to 0.6 g.

Robinson Aviation Inc.

Circle 110 on postcard for more data

Die, And Stainless Steels Being Used In Fasteners

Aircraft type fasteners are being fabricated from high alloy die steels and a variety of stainless steels.

The new materials permit use of smaller, lighter components with no sacrifice in strength. They are recommended for use in elevated temperature applications where unusual strength is needed.

Among the new Huckbolt pin materials that may now be specified are AISI Types 321 and 431 stainless steels, A286 and 17-4 PH stainless steels, Vasco Jet 1000 alloy steel and Thermold J alloy steel. Huckbolt collars for these applications are of AISI Type 430 stainless steel.

Huck Manufacturing Co.

Circle 106 on postcard for more data

PRECISION GYRO TEST TURNTABLE

A high precision, rugged piece has been designed for testing low-drift gyros in either open or closed loop. Easy accurate tilting permits polar axis drift tests as well as vertical, inverse vertical and horizontal axis drift tests, all without changing the position of the gyro on the turntable.

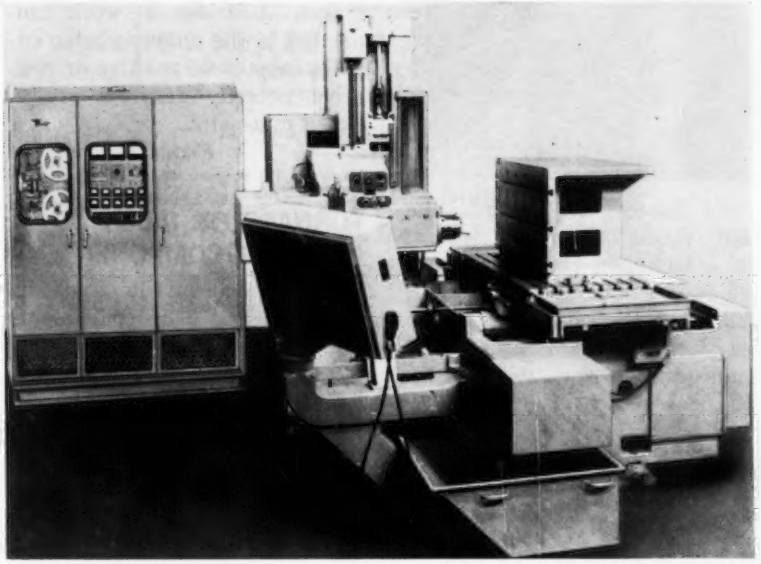
Turntable drive is by smooth, precision geared servomotor, with alternative step rate drive. Basic accuracy of the master precision rotation dial is two secs of arc. The gearing and the slip rings are completely enclosed. There is a two-speed synchro table rotation transmitting system for remote recording.

Dimensions: turntable, 14 in.; overall diameter, 24 in.; height 54 in.; Total weight 900 lb.

Sterling Precision Corp.

Circle 130 on postcard for more data

NUMERICAL CONTROL FOR TOOL CUTTING FUNCTIONS



Electronic numerical control system guides machine tools in milling, turning, jig boring and drilling. Production lead time savings of up to 75 per cent are claimed since no templates, cams or models are required. Information from design drawings is produced on a plastic control tape by a small digital computer. The tape is then installed in the control unit.

Bendix Aviation Corp.

Circle 127 on postcard for more data

LATHE ATTACHMENT EASES OPERATION

A versatile attachment, adaptable to almost all lathes, makes it possible for relatively unskilled labor to perform such turning applications as step shaft tracing, contour turning, and facing operations.

Based on a hydraulic 180° single dimension tracer, the attachment converts standard lathes to contour machines, still allows normal turning by the lathe because cross and longitudinal screws are kept intact.

Cross and tool slides are cast of Meehanite.

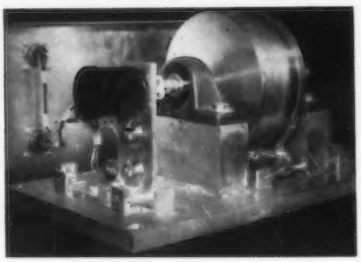
True-Trace Sales Corp.

Circle 119 on postcard for more data

PRECISION UNIT MEASURES STRESSES

A new high precision, flexible deflection sensor has been developed for testing airframe and missile parts under both static and dynamic conditions.

The unit consists of a non-elastic cable wrapped around a grooved drum of about five in. diam. The free end of the cable may be terminated through cementing or other fastening to the part to be tested.



Cable drum, of aluminum to minimize moment of inertia lags, is spring loaded to maintain constant tension on the sensing cable throughout its entire range of 96 in.

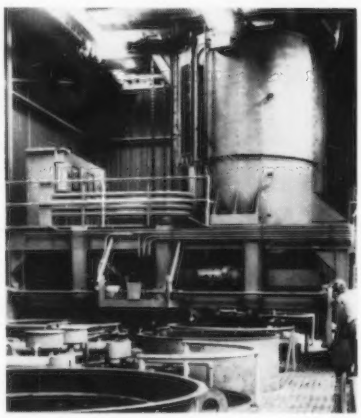
The drum shaft, supported by two ball bearing pillow blocks, is coupled to a ten-turn potentiometer powered from from a d-c source. This provides electrical output linearly proportional to the cable travel. A bridge network connection to the potentiometer enables outputs of positive or negative polarity from a pre-selected mid-point.

Frank R. Cook Co.

Circle 129 on postcard for more data

FURNACE ON RAILS HARDENS COMPONENTS

Guided missile and aircraft landing gear components are hardened in a new gantry-type controlled atmosphere furnace on rails.



Structure is raised on side supports to span either a preloading station or adjacent oil and salt quench tanks.

Reinforced furnace shell, nine ft. in diam by 16 ft. deep, is welded gas tight to prevent contamination by air. It accommodates a loading fixture with an effective work load 12 ft. long by five ft. diam.

Heating elements employed for temperatures to 1850°F are of 80 per cent nickel and 20 per cent chromium analysis. Mounted on four 18 in. diam wheels, furnace can be moved along the furnace pit by pushbutton control.

Heat Treating Div.
Lindberg Engineering Co.

Circle 121 on postcard for more data

LIGHTWEIGHT GUN ATOMIZES, SPRAYS

A new portable "Burp Gun" for spraying or mold filling with polyurethane or polyester has been announced. Made of lightweight materials, it is equipped with two interchangeable nozzles for horizontal or vertical spraying or, with a twist of the wrist, it is converted into a mold or void-filling unit.

Internally mixed, each formulation component is atomized individually within the body of the gun and again when

continued on page 69

for full facts on

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new production equipment
advertiser's products and services
copies of technical literature

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advertisers in this issue

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Line, terminal, insulated

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Machines, hydroform—hydrospin

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Brochure, gaging

62 **Hamilton Tool Co.**
Machine, small-gear, hobbing

51 **Heald Machine Co.**
Analysis, replacement

63 **Hunter Mfg. Co.**
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Rings, proving

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65 **Sealol Corp.**
Seals, gas and fluid

70 **Stewart Corp., F. W.**
Shafting, flexible

68 **Synchro-Start Products, Inc.**
Switches, speed, sensitive

55 **Tapmatic Corp.**
Attachments, tapping

61 **True-Trace Corp.**
Controls, machine tool

58 **Vinson Mfg. Co.**
Regulator, flow

MATERIALS AND COMPONENTS

Alphabetical List of Products

100 **Alloy, cast**
South Gate Aluminum and Magnesium Co.

101 **Alloy, brazing**
Wall Colmonoy Corp.

102 **Bearings, "wafer"**
New Hampshire Ball Bearings

103 **Control Valve, brake T**
Tactair Valve Div. Aircraft Products Co.

104 **Drive gears, right angle**
Airborne Accessories Corp.

105 **Fastener, explosive**
Beckman and Whitley Inc.

106 **Fasteners, huckbolt**
Huck Manufacturing Co.

107 **Focus Coil**
Syntronic Instruments Inc.

108 **Fuel Pump**
Chandler Evans

109 **Lamp, miniature**
Chicago Miniature Lamp Works

110 **Mounting, Gyroscope**
Robinson Aviation, Inc.

111 **Relay, micro miniature**
Guardian Electric Mfg. Co.

112 **Seal, dual purpose**
Skinner Seal Co.

113 **Servo repeater, miniature**
Waldorf Instrument Co.

114 **Steel cable, non rotating**
Bergen Wire Rope Co.

115 **Transducer, high temperature**
G. M. Gianni and Co., Inc.

116 **Vacuum Pump**
Pesco Products

117 **Valve, air control**
Vap Air Div.,
Vapor Heating Corp.

118 **Valves, hydraulic, pneumatic**
Skyvalve, Inc.

Alphabetical List of Companies

104 **Airborne Accessories Corp.**
Drive Gears, right angle

105 **Beckman and Whitley Inc.**
Fastener, explosive

114 **Bergen Wire Rope Co.**
Steel cable, non rotating

108 **Chandler Evans**
Fuel Pump

109 **Chicago Miniature Lamp Works**
Lamp, miniature

115 **G. M. Gianni and Co., Inc.**
Transducer, high temperature

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Relay, micro miniature

106 **Huck Manufacturing Co.**
Fasteners, huckbolt

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Bearings, "wafer"

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Vacuum Pump

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Mounting, Gyroscope

112 **Skinner Seal Co.**
Seal, dual purpose

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Readers Service Dept.

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118 **Skyvalve, Inc.**
Valves, hydraulic, pneumatic
100 **South Gate Aluminum and Magnesium Co.**
Alloy, cast
107 **Syntronic Instruments Inc.**
Focus Coil
103 **Tactair Valve Div. Aircraft Products Co.**
Control Valve, brake T
117 **Vapor Heating Corp. Vap Air Div.**
Valve, air control
113 **Waldorf Instrument Co.**
Servo repeater, miniature
101 **Wall Colmonoy Corp.**
Alloy, brazing

NEW FOR PRODUCTION

Alphabetical List of Products

119 **Attachment, lathe**
True-Trace Sales Corp.
120 **Controller, indicating**
U. S. Gauge Div.
American Machine & Metals Inc.
121 **Furnace, hardening**
Lindberg Engineering Co.
122 **Gun, spraying**
Tri-Kris Co. Inc.
123 **Indicator, scratch**
Boeing Airplane Co.
124 **Lathe, turret**
Potter & Johnston Co.
125 **Mandrel, flexible**
Pines Engineering Co.
126 **Miller, tape controlled**
General Electric Co.
127 **Numerical Control**
Bendix Aviation Corp.
128 **Probe, box**
Rosemount Engineering Co.
129 **Sensor, deflection**
Frank R. Cook Co.
130 **Turntable, gyro**
Sterling Precision Corp.

Alphabetical List of Companies

120 **American Machine & Metals Inc. U. S. Gauge Div.**
Controller, indicating
127 **Bendix Aviation Corp.**
Numerical Control
123 **Boeing Airplane Co.**
Indicator, scratch
129 **Frank R. Cook Co.**
Sensor, deflection
126 **General Electric Co.**
Miller, tape controlled
121 **Lindberg Engineering Co.**
Furnace, hardening
125 **Pines Engineering Co.**
Mandrel, flexible
124 **Potter & Johnston Co.**
Lathe, turret
128 **Rosemount Engineering Co.**
Probe, box
130 **Sterling Precision Corp.**
Turntable, gyro
122 **Tri-Kris Co. Inc.**
Gun, spraying
119 **True-Trace Sales Corp.**
Attachment, lathe

JULY, 1958 ●

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Mounting, Gyroscope
112 Skinner Seal Co.
Seal, dual purpose

WORTH ASKING FOR—Alphabetical List of Items

131 Aircord
John A. Roebling's Sons
132 Bearings, anti-friction
Industrial Tectonics Inc
133 Boring Head
P. M. Instrument Co.
134 Chart, selector
Lewis Shepard Products
135 Cleaning, ultrasonic
Branson Ultrasonic Corp.
136 Computer Method
Bendix Computer Div.
137 Controls, machine tool
True-Trace Sales Corp.
138 Digest, catalog
Panoramic Radio Products
139 Drives, servo
Vickers, Inc.
140 Facilities Bulletin
Leland Electric Co.
141 Fasteners
Monadnock Mills
142 Gages, missile
Federal Products Corp.
143 Insulating, silicon
Dow Corning Corp.
144 Melting, vacuum arc
Oregon Metallurgical Corp.
145 Mounting system, Atlas
Lord Manufacturing Co.
146 Pilot Lights
Dialight Corp.
147 Plugs, cannon
Cannon Electric
148 Soldering
The Deutsch Co.
149 Tantulum Sheet
Fansteel Metallurgical Corp.
150 Teflon
Raybestos-Manhattan, Inc.
151 Thermocouples, miniature
Thermo Electric Co.
152 Tools, cutting
Severance Tool Industries
153 Tools, machine
Snyder Tool Engineering Co.
154 Vise Catalog
Desmond-Stephen Mfg. Co.

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Alphabetical List of Companies

136 Bendix Computer Div.
Computer Method
135 Branson Ultrasonic Corp.
Cleaning, ultrasonic
147 Cannon Electric
Plugs, cannon
154 Desmond-Stephen Mfg. Co.
Vise Catalog
148 The Deutsch Co.
Soldering
146 Dialight Corp.
Pilot Lights
143 Dow Corning Corp.
Insulating, silicon
149 Fansteel Metallurgical Corp.
Tantulum Sheet
142 Federal Products Corp.
Gages, missile
132 Industrial Tectonics Inc.
Bearings, anti-friction
140 Leland Electric Co.
Facilities Bulletin
134 Lewis Shepard Products
Chart, selector
145 Lord Manufacturing Co.
Mounting system, Atlas
141 Monanock Mills
Fasteners
144 Oregon Metallurgical Corp.
Melting, vacuum arc
138 Panoramic Radio Products
Digest, catalog
133 P. M. Instrument Co.
Boring Head
150 Raybestos-Manhattan, Inc.
Teflon
131 John A. Roebling's Sons
Aircord
152 Severance Tool Industries
Tools, cutting
153 Snyder Tool Engineering Co.
Tools, machine
151 Thermo Electric Co.
Thermocouples, miniature
137 True-Trace Sales Corp.
Controls, machine tool
139 Vickers, Inc.
Drives, servo

122 Tri-Kris Co. Inc.
Gun, spraying
119 True-Trace Sales Corp.
Attachment, lathe

COMPANY .....
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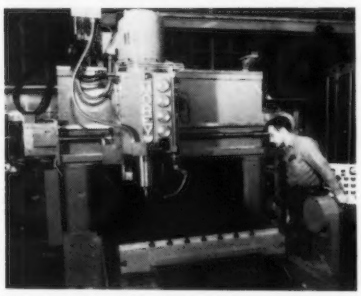
mixed together in the nozzle. This method is designed to assure thorough mixing of the formulation and reduce overspray. The internal-mix feature contains no moving parts to wear and avoids clogging and complex cleaning problems.

Tri-Kris Co., Inc.

Circle 122 on postcard for more data

MILLING MACHINE FOR SMALL PRODUCER

Aircraft components can be produced in small lots with a magnetic tape-controlled milling machine. Designed to make such production economically feasible for the small and medium-sized plant, the Morey Machine Co. profile and contour miller fashions precision parts from ferrous and non-ferrous metals as large as 48 in. x 48 in. x 12 in.



Feed motions on vertical, horizontal and longitudinal axes are numerically controlled at rates up to 100 in. per min. and tolerances as low as .001 in. Similar tolerances are possible at traverse of 200 in. per min.

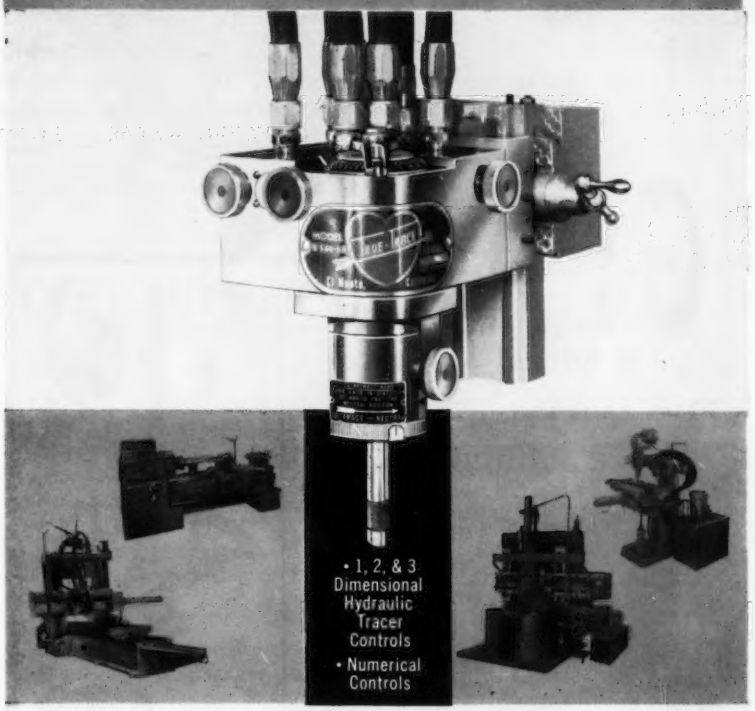
Tape control for the small miller was developed by G. E.'s specialty control dept.

General Electric Co.

Circle 126 on postcard for more data

continued on next page

"AUTOMATE" YOUR MANUAL MACHINES
...WITH TRUE-TRACE CONTROLS!



Outmoded, manually-operated machines cost money, reduce production capacity and waste skilled labor. Modernize your existing machines with **True-Trace** machine tool controls—increase your ability to produce high quality parts economically.

Our factory representatives from coast to coast, and three factory sales, engineering and service centers are ready to show you how to increase production on your contoured parts or straight line machining ... yet achieve close tolerances! Let us assist you with your contour machining problems.

Before specifying ordinary controls, check **all** the facts ... investigate ... get expert in-plant recommendations. See why **more** True-Trace controls are used as original equipment by **more** machine builders than all other controls combined. **Write for our new 24-page, illustrated bulletin SB-1—TODAY!**

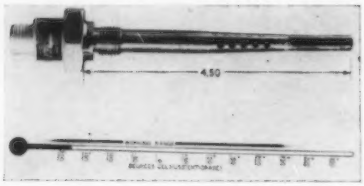
"Sponsors of the Contour Machining Conferences"

TRUE-TRACE SALES CORPORATION
9830 E. Rush St., El Monte 35, California
Branch Plants: 35 Urban Ave., Westbury, Long Island, New York
2401 Eaton Lane, Racine, Wisconsin
Dealers in Principal Cities

Drives, servo

LOX PROBE HAS WIDE RANGE

Liquid oxygen temperature probe possesses working range from —200°C or lower to +250°C or higher.



Still being tested for application down to the liquid helium range, the probe provides 100 ohm variation from —270 to —300°F, corresponding to pure platinum wire with 1380 ohms resistance at 0°C.

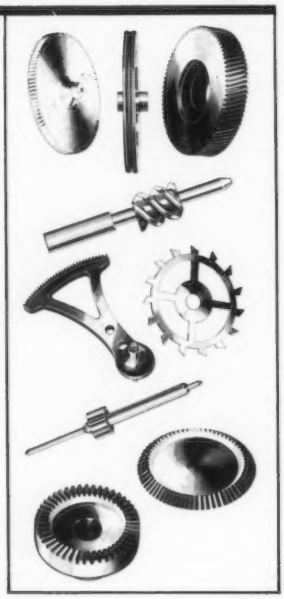
Rosemount Engineering Co.

Circle 128 on postcard for more data

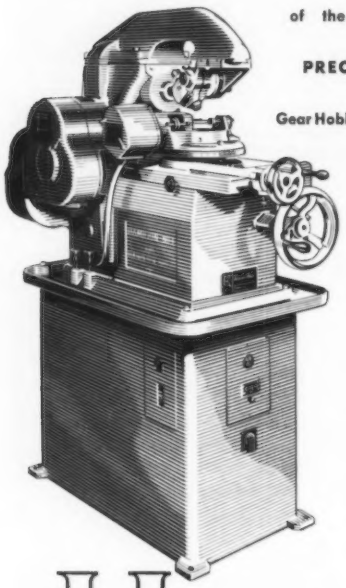
-GEARS

. . . to critical tolerances

2681



Aircraft and Missile men • • • • your precision gear problems can be solved • • simply • • by application of the Hamilton **PRECISION** Gear Hobbing Machine



• • • an **AMERICAN** machine • • • • designed and built especially for work like yours. Write • • • now • • • for our free literature packet No. GH 840.

Hamilton

PRECISION SMALL-GEAR HOBBING MACHINE

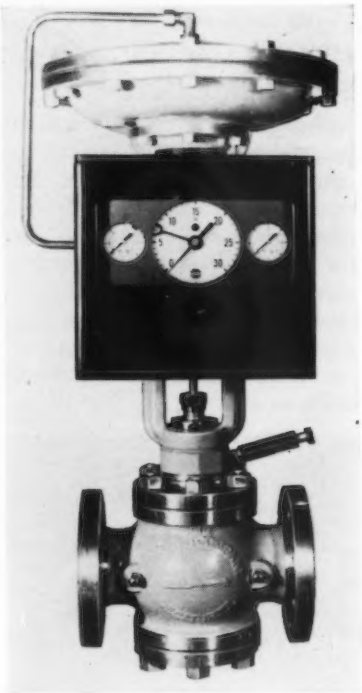
THESE ARE REPRESENTATIVE USERS OF HAMILTON GEAR HOBBING EQUIPMENT

AiResearch Manufacturing Co. • Duncan Electric Co. • Bendix Aviation Corp. • Victor Adding Machine Co. • Lear, Co. Minneapolis-Honeywell Regulator Co. • Geophysical Machine Works • Hughes Aircraft Co. • Westinghouse Electric Corp. • Rockwell Meters, Inc. • Borg Products Division • Herschede Hall Clock Co. • U. S. Navy Electronics Laboratory • Redstone Arsenal • Smallwood & Son Machine Co. • Link Aviation, Inc. • Bell Aircraft • General Mills • Elgin National Watch Co. • U. S. Naval Gun Factory • Grimes Manufacturing Co. • Texas Instruments, Inc. • McDonnell Aircraft Co. • American Machine & Metals • Stromberg-Carlson Co. • Hamilton Standard • U. S. Gauge Co. • Western Gear Works • Schlumberger Well Surveying Corp. • Douglas Aircraft.

THE HAMILTON TOOL COMPANY • 882 SOUTH NINTH STREET • HAMILTON, OHIO

INDICATING CONTROLLER HAS REFINED CONTROL

The "Pilot," a new indicating controller, is designed to meet industry's needs for a compact low-cost pneumatic controller. It can provide two position control and wide band proportional with or without automatic reset or rate action.

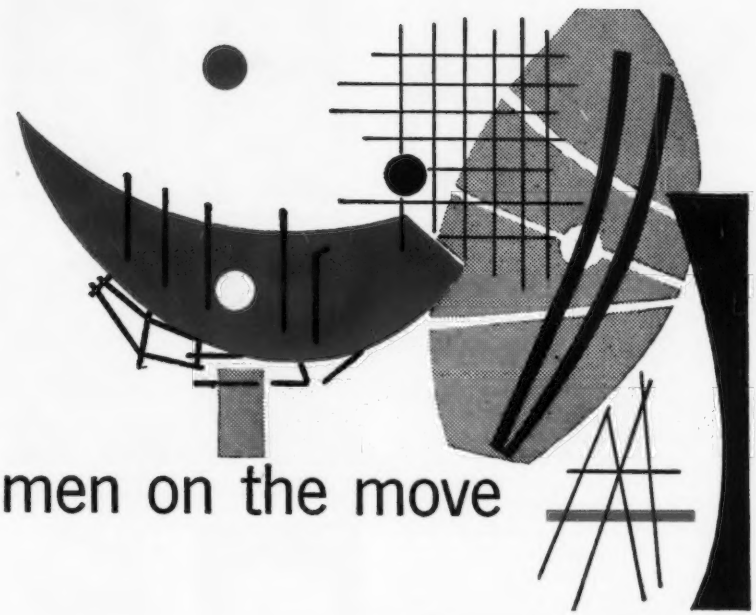


Primarily for temperature or pressure control, the product measures 8½ in. square by four in. deep, and can be surface-mounted on equipment or flush-mounted on instrument panelboards. It can also be mounted directly on the pneumatic-operated valve that it positions.

U. S. Gauge Div., American Machine and Metals, Inc.

Circle 120 on postcard for more data

continued on page 74



men on the move

JACK MOTT has been named asst. general manager of Wright Engineering Co.

N. W. LANDIS has been named manager of the northeast region, Allis-Chalmers Industries Group.

RICHARD S. MORSE, president of National Research Corp., has been appointed chairman of the Army Scientific Advisory Panel.

ROBERT STRICH was named chief engineer, Los Angeles Div., Cannon Electric Co.

CHARLES W. SNIDER has been named director of government relations for the Defense Operations Div., Chrysler Corp.

DEWEY H. NELSON has been promoted to division manager, Becco Chemical Div., Food Machinery and Chemical Corp.

L. R. SWIFT has been promoted to the newly created post of special asst. to the manager of production, Aeronautical Div., Minneapolis Honeywell Regulator Co.

EDWARD LUND has been named to succeed Swift as director of production.

KENNETT W. PATRICK was named a vice president of Consolidated Electrodynamics Corp.

FRANK M. JENNER was named vice-president, Rochester Div.

WALTER H. OWEN was named general manufacturing superintendent, Apparatus Div., Texas Instruments Inc.

EARL L. CASEY was named manager of division services for TI.

I. NEVIN PALLEY has been promoted to the newly created position of senior vice president, Temco Aircraft Corp.

ROBERT E. GALER has been promoted to vice president, engineering.

DOUGLAS T. MC GINTY, assistant to the president of Steel Improvement and Forge Co., is on loan from his firm to become chief of the forgings branch, Business and Defense Services Adm.

EDWIN B. JAMES was appointed vice president, sales, The McKay Machine Co.

GEORGE A. LAGASSA is new president—manufacturing of Titeflex Inc.

GEORGE W. HOSTETTLER has been promoted to manager of Beech Aircraft Corp's Boulder Div.

A. L. CLARK has been promoted to manager of engineering and sales for the division.

STEPHEN A. BUSCH was appointed director of manufacturing, Fluid Systems Div., Waldorf Instrument Co.

HAROLD W. SCHMID, vice president of General Metals Corp., has also been made general manager of the firm's foundry and forge plants in Los Angeles.

HENRY B. POPP was appointed western sales representative, subcontracts, Lycoming Div., Avco Manufacturing Corp.

D. WAYNE ZIMMERMAN was named manager of the Automatic Warehousing Branch, Pesco Products Div., Borg-Warner Corp.

CLAUDE H. SMITH has been named director of contract management for the Aeronautical Div., Minneapolis-Honeywell Regulator Co.

Edwin B. James
McKay Machine Co.

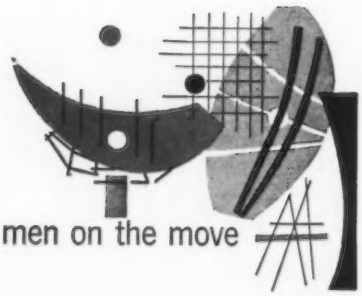
George A. Lagassa
Titeflex Inc.

Stephen A. Busch
Waldorf Instrument Co.

Harold W. Schmid
General Metals Corp.

D. Wayne Zimmerman
Pesco Products

Claude H. Smith
Minneapolis-Honeywell
Regulator Co.



ROBERT J. HIGLEY has been named vice president in charge of planning of Hupp Aviation Co.

CHARLES F. COBDEN has been promoted to controller.

JAMES PETERSON has joined the Cyril Bath Co. as chief engineer.

ROBERT E. KEMELHOR has been named manager of future product planning and development for the Pesco Products and Wooster Divisions of Borg-Warner Corp.

FRANK ROODMAN was named engineering coordinator for missile projects by the Austin Co.

R. J. QUIGLEY was appointed manager of the Aircraft Sales Div., Field Aviation Co.

ROBERT W. STRICKLAND has been named manager of The Trane Co. Providence, R. I., sales office.

DR. NICHOLAS A. BEGOVICH has been named director of engineering for the Ground Systems Group, Hughes Aircraft Co.

EDWARD J. COUSIN has been named manager of space and missile programs for Allen B. Du Mont Laboratories, Inc.

G. Q. DECKER was elected vice president of Servomechanisms Inc.

DAN W. BURNS has been elected president of the Hufford Corp.

JESSE H. ZABRISKIE has been appointed asst. manager, systems test dept., Boeing Pilotless Aircraft Div.

JAY R. BORDEN is new senior instrumentation engineer of Waste King Corp's Technical Products Div., Los Angeles.

F. DONALD DILDINE has been named director of purchasing for Chandler Evans Co.

Robert J. Higley
Hupp Aviation Co.

W. T. Harmon
General Electric Co.

James Peterson
Cyril Bath Co.

George H. Hoeck
Chicago Aerial
Industries Inc.

Frank Roodman
The Austin Co.

R. Adm. G. H. DeBaun
Aircraft Radio Corp.

Dr. Nicholas A.
Begovich
Hughes Aircraft Co.

Eugene J. Vigneron
Sylvania Electronic
Systems

Edward J. Cousin
Du Mont Laboratories

W. S. Bobier
Vickers Inc.

F. Donald Dildine
Chandler Evans Co.

W. Dee Shepherd
Mason, Shaver &
Rhoades

W. T. HARMON has been named manager of marketing for the Production Engine Dept., General Electric Co.

PRESSON S. SHANE has been appointed director of the Solid Propellant Div.

ROBERT O. WEBSTER becomes director of the new Mechanical Engineering Div.

ROSS H. BEGG, JR. has been promoted to asst. to the general manager at Pratt & Whitney Aircraft.

GEORGE H. HOECK has been elected vice president and director of manufacturing of Chicago Aerial Industries Inc.

ROBERT K. LOWRY was named western regional manager.

K. A. JONSSON was appointed western region sales manager for the Semiconductor-Components Div., Texas Instruments Inc.

R. ADM. G. H. DE BAUN (USN Ret.) has been elected a director of Aircraft Radio Corp.

M. LEE RICE has been elected vice president of Atlantic Research Corp.

EUGENE J. VIGNERON will be manager of the new Needham, Mass. plant being opened this month by Sylvania Electronic Systems.

JOHN B. DONER was named project manager of Sylvania's electronic defense subsystem contract for the B-52 bomber.

GEORGE A. GOODWIN was elected chairman of the board, American Society of Tool Engineers, at the society's annual convention.

W. S. BOBIER has been appointed chief engineer, Detroit activity, Aero Hydraulics Div., Vickers Inc.

DR. JOSEPH M. DENNEY has joined the nuclear electronics dept., Hughes Aircraft Co.

ELLIOTT MEHRBACH has been appointed chief engineer, Communications Div., Topp Manufacturing Co.

W. DEE SHEPHERD joins Mason, Shaver & Rhoades Sales Inc. as vice president in charge of marketing.

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Machine Tool Controls

Catalog gives general treatment of machine tool controls, accessories and conversions.

True-Trace Sales Corp.

Circle 137 on postcard for more data

Tantalum Sheet

Price list covers tantalum sheet and foil, both mill and stock, for all end uses except capacitors.

Fansteel Metallurgical Corp.

Circle 149 on postcard for more data

Vise Catalog

A 16-page catalog illustrates and describes operations and features of the machinist's vise line.

The Desmond-Stephen Mfg. Co.

Circle 154 on postcard for more data

Anti-Friction Bearings

Special bearings for the space age are detailed in brochure.

Industrial Tectonics, Inc.

Circle 132 on postcard for more data

Cutting Tools

1958 catalogue gives complete line of cutting tools with prices and descriptions.

Severance Tool Industries Inc.

Circle 152 on postcard for more data

Aircord

Elastic and thermal properties of aircord are described in illustrated report.

John A. Roebling's Sons Corp.

Circle 131 on postcard for more data

Vacuum Arc Melting

Techniques and applications of vacuum arc melting and casting are explained in illustrated brochure.

Oregon Metallurgical Corp.

Circle 144 on postcard for more data

Atlas Mounting System

Design of special electronic mounting system for Atlas ICBM is included in "Dynafacts" quarterly.

Lord Manufacturing Co.

Circle 145 on postcard for more data

Servo Drives

A 12-page bulletin treats hydraulic servo drives for weapons systems developed and produced during the last 20 years.

Vickers Inc.

Circle 139 on postcard for more data

Boring Head

Brochure describes boring head giving direct readings up to 0.0001 in.

The P. M. Instrument Co.

Circle 133 on postcard for more data

Teflon

Sizes and properties of Teflon Raylon and Kel-F tubes, rods, gaskets, joints and rings are given in 31-page brochure.

Raybestos-Manhattan, Inc.

Circle 150 on postcard for more data

Fasteners

New catalog describes complete uses of Airloc fasteners, plus pertinent engineering data.

Monadnock Mills

Circle 141 on postcard for more data

Catalog Digest

A 1958 catalog digest includes instruments, complete instrumentation system, improved features, and brief informative descriptions.

Panoramic Radio Products Inc.

Circle 138 on postcard for more data

Cannon Plugs

A lighter, shorter version of the MS-E line of Cannon Plugs is described in a new catalog covering all type "E" Cannon plugs conforming to the provisions of Military Standard MIL-C-5015.

Cannon Electric Co.

Circle 147 on postcard for more data

Machine Tools

A 20-page, two-color catalog describes automated special machine tools for low, medium and high-production operations.

Snyder Tool Engineering Co.

Circle 153 on postcard for more data

Missile Gages

Brochure describes types of gages for measuring critical dimensions and dimensional relationships in a variety of critical parts for guided missiles.

Federal Products Corp.

Circle 142 on postcard for more data

Soldering Techniques

A ten-page report gives a step by step procedure for the soldering of miniature electrical connectors.

The Deutsch Co.

Circle 148 on postcard for more data

Silicone Insulating

Silicone insulating systems are described in a new eight-page brochure. Both resinous and rubber like systems are discussed.

Dow Corning Corp.

Circle 143 on postcard for more data

for mobile and portable military shelters

- designed and produced in accordance with military specifications for space, equipment and personnel heating requirements.
- 5 basic models — each custom-engineered for a wide variety of applications — for ground control and maintenance equipment in missile systems, radar, microwave and radio communication systems, etc.
- BTU/Hour range: from 15,000 to 60,000.
- multi-fuel-burning models; also models which burn any type gasoline.
- all models air-circulating, thermostatically controlled, all designed for cold starts as low as — 65°F.

Other Hunter equipment for military applications: engine heaters; unpowered, instant lighting torches; refrigeration units.

GET THESE BROCHURES TODAY!

for complete specifications and details

HUNTER MANUFACTURING CO.
30537 AURORA RD.
SOLON, OHIO
HEATING AND REFRIGERATION SYSTEMS

Circle 63 on Inquiry Card, page 65

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Miniature Thermocouples

A consolidated 28-page catalog describing complete line of miniature thermocouples is available. Four basic designs are described and illustrated—Gasket, Bayonet, Protected and Shielded.

Thermo Electric Co., Inc.

Circle 151 on postcard for more data

Facilities Bulletin

Completely integrated research, design, development and production facilities for aircraft and missile subsystems and components are described in Bulletin 2100.

The Leland Electric Co.

Circle 140 on postcard for more data

Continued from page 70

Computer Method

A four-page bulletin describes features of a new programming method. System (known as Intercom 1000) has been designed for use with the Bendix G-15 general purpose digital computer.

Bendix Computer Div.

Circle 136 on postcard for more data

Pilot Lights

New digest consists of 16 pages of condensed technical information on a wide range of Dialco Pilot Light Assemblies and the appropriate lamp types.

Dialight Corp.

Circle 146 on postcard for more data

Selector Chart

New circular 26B, designed to simplify selection of hand lift trucks, is available.

Lewis Shepard Products Inc.

Circle 134 on postcard for more data

Ultrasonic Cleaning

24-Page Bulletin s-200, 8½ x 11 in. in size, explains practical applications and basic principles of ultrasonic cleaning as well as design of equipment.

Branson Ultrasonic Corp.

Circle 135 on postcard for more data

INDICATOR SHOWS DEPTH OF SCRATCHES

Manufacturing research engineers have developed a new optical instrument for measuring depth of scratches.

Instrument, standing seven in. high, has a set of lenses with 36 x magnification, and works on the principle used by astronomers for measuring the depth of moon craters. A light source strikes the bottom of the scratch or pit at a known angle and the length of the shadow is measured automatically by the instrument. Calibrations on a simple adjustment knob give depth measurements to one ten-thousandth of an inch.

The indicator can also measure thickness of paint and flushness of abutting surfaces.

Boeing Airplane Co.

Circle 123 on postcard for more data

FLEXIBLE MANDREL

A new type of flexible ball mandrel, the "Free-Flex," is designed to make top-quality bends to a radius of 2-D (centerline-2x tube diam) in thin wall tubes.

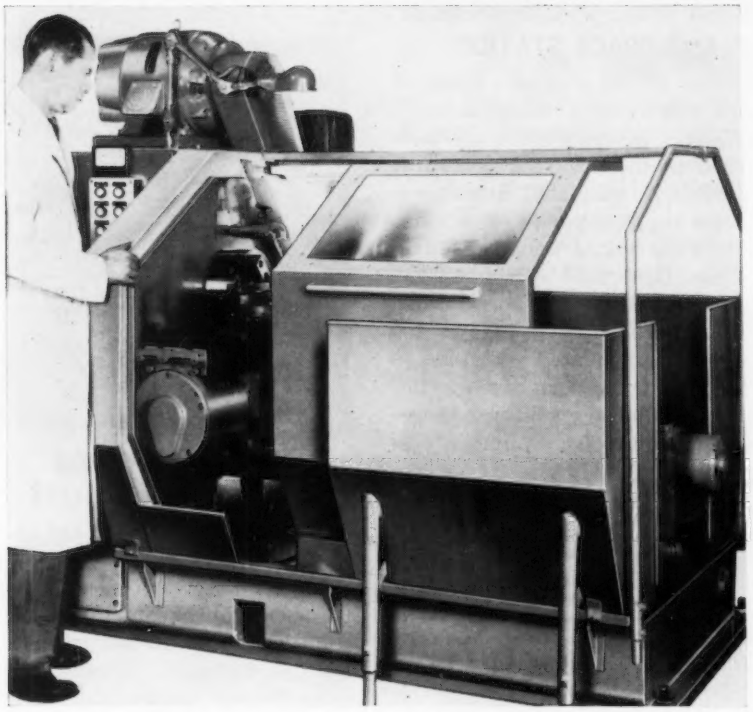
The mandrel uses a threaded pin with a spherical head to hold a series of balls together. The spherical head of pin fits into a spherical seat in the ball permitting movement in any direction. This design and construction combines the flexibility of a cable mandrel with the strength of a link mandrel.

Available in diameters from one to six in., the mandrels are constructed of steel for bending non-ferrous and carbon-steel tubing and Ampco-coated steel or solid Ampco.

Pines Engineering Co.

Circle 125 on postcard for more data

HIGH-SPEED TURRET LATHE FEATURES FAST SET-UP



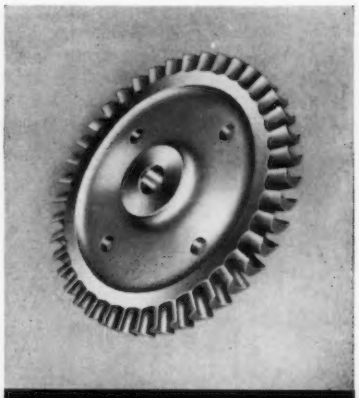
An all-new automatic turret lathe has been designed for high speed production of hard-to-machine tough alloy components. With a 10-in. chuck capacity and 11½ in. swing over base ways, the small heavy-duty machine is equipped with an entirely new 15 hp headstock, all-electric speed clutches and precision ground speed gears. Rugged construction withstands strains of hogging out tough metal fast with heavy feeds under full power.

The independent front and rear cross slides are individually adjustable along the base ways. Operator can set front or rear slide for on-time or delayed movement relative to any turret face by merely turning a selector switch.

Since there are no cams to change, set-up time has been substantially reduced. The lathe has four automatic speed changes and six automatic feed changes for each set of change gears.

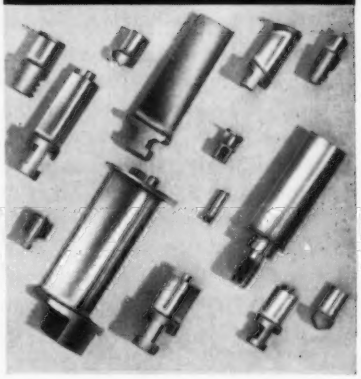
Potter and Johnston Co.

Circle 124 on postcard for more data



• wheels
• blades
• buckets

Schellens-True Corp.



The Schellens-True organization is devoted exclusively to the manufacture of turbine blades, wheels, vanes and nozzles of all types, machined from a wide variety of alloys and materials. We have developed entirely special automatic blade and wheel machining equipment available nowhere else. Creative engineering, precision manufacturing and rigid quality control assure a reliable product at a minimum cost.

May we quote on your requirements?

SCHELLENS-TRUE CORP.
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West Coast Representative:
Jessup Engineering Company
8703 LaTijera Blvd.
Los Angeles 45, California

15718

Circle 64 on Inquiry Card, page 65

industry notes

CONVAIR-ASTRONAUTICS PLANS SPACE STATION

A four-man experimental space station, launched by Atlas and orbiting 400 mi above the earth, has been proposed by the Convair (Astronautics) Div. of General Dynamics Corp.

According to the proposal which the firm says could be a reality within five years from starting date, an Atlas without nose cone or associated weapons gear would be fired into orbit. The shell would be equipped as a space station.

In illustration, Krafft Ehricke, asst. to the technical director of Convair-Astronautics, shows clear acrylic plastic model of the station. Scale of the nine-ft long model is 1:10. Wooden escape gliders are fastened to the back for return to earth. A simulated atomic reactor supplies power. Black fins dissipate heat. Diaphanous model was fabricated by Blaine Electronetics, Inc., Van Nuys, Calif.

Crew capsule shows the inflatable insulated structure in the forward section of the cylindrical vehicle. Aft end is reserved for heavy equipment including humidifier, air conditioning, a water distilling and purification machine, and other environmental controls.

NEW TAKEOFF SYSTEM GIVES JETS VERSATILITY

A North American F-100D Super Sabre has been launched directly from a mobile trailer with the aid of a solid propellant 130,000-lb-thrust Astrodyne rocket.

First successful Zero Length Launch by a century series jet, the test was part of the Air Force program to be able to launch fighter bombers without using conventional runways.

The plane is pulled into firing position on the launcher by a self contained winch. Booster on the underside of the aft fuselage is triggered after the pilot has started the jet engine and cut in his after-burner. Prior to burnout, pilot and plane are subjected to 3g acceleration.

MARTIN AND BOEING PICKED FOR DYNA-SOAR

The Air Force has selected Martin Co. and Boeing Airplane Co. as contractors for the advance boost-glide aircraft, Dyna-Soar.

As sources of development, Martin and Boeing will each head teams of five or six of the most able contractors in the aircraft industry. The Department of Defense said Martin will draw heavily on Bell Aircraft Corp.'s investigation in the boost-glide field, and both contractors will call on the specialized abilities of contractors throughout the country.

Early developments by the two contractors will be competitive to insure the most advanced and complete designs.

The National Advisory Committee for Aeronautics and the Air Force will be partners in managing the Dyna-Soar project, which will investigate manned space flight. Projected capabilities include "from one to many earth orbits followed by a normal landing," according to the Department.

BELL X-14 TAKES OFF FROM HORIZONTAL PLANE

The Bell X-14, experimental jet-powered plane, has successfully completed a flight in which takeoff and landing were straight up and down similar to a helicopter.

Built for the Air Force by Bell Aircraft Corp., the X-14 rose horizontally, flew to 160 mph, braked to a full stop 10 ft from the ground from 95 mph speed, made a 180° hovering turn and settled to the surface.

Two Armstrong Siddeley Viper jet engines provide more than 3500 lb thrust. On takeoff, this is deflected downward by venetian-blind type vanes behind the engines. In forward flight, the thrust is directed rearward.

FINAL ASSEMBLY FOR BOEING 707-320

The first long-range Boeing 707-320 Intercontinental jet airliner is shown on final assembly line at Boeing's Transport Div., Renton, Wash.

Pan American World Airways will receive the first of the 296,000 lb, 600 mph airliners in 1959.

Nearing completion on the back leg of the horseshoe shaped final assembly line can be seen the sixth Stratoliner destined for Pan American followed by the first two 707's for American Airlines.

WHICH SEAL WILL SOLVE YOUR PROBLEM?

Seals drawn to same scale.				
Type of Seal	**Standard**	**Modified**	**Bellows**	**Shaft Surface**
Pressure (PSI)	1000	500	250	75
Speed (FPM)	15,000	15,000	15,000	15,000
Temperature (°F)	350° to 450°	—360° to 350°	—360° to 700°	500° to 700°
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Send for	Bull. #7	Specially enginered	Bull. #18	Bull. #19

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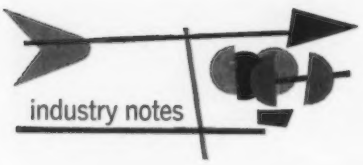


NAVY'S CRUSADER III TO PROTECT FLEETS

First test flight of the Crusader III, Chance Vought's push-button Mach 2 interceptor, has been completed at Edwards Air Force Base, Calif., three months ahead of schedule.

Built for the Navy, the all-weather fighter is capable of flying above 95 per cent of the earth's atmosphere. Its automatic guidance includes "mach hold," and "altitude hold" buttons. Called F8U-3 by the Navy, the Crusader is 58 ft, 8.8 in. long; 16 ft, 4.5 in. high; with 39 ft span. It is powered by the Pratt & Whitney J-75 with nearly 26,000 lb thrust.

A two position wing makes it possible to fly at high speed and yet land on a carrier.

REPUBLIC TO BEGIN PRODUCTION OF F-105

Republic Aviation Corp. goes into volume production this Fall of the supersonic F-105 Thunderchief fighter - bomber, with production schedules running through 1960.

First production unit of the larger fighter, being built for the Tactical Air Command, rolled out of final assembly recently at Farmingdale, L.I. Operational testing of the jets by TAC and ARDC will take place at Eglin Air Force Base, Fla. with pilots being the same men who will fly the first tactical squadron.

First wing of the F-105's is scheduled to go into service with TAC sometime in 1959. Six years in development, the planes, 63 ft long with 34 ft wingspan, are capable of delivering atomic weapons at speeds near Mach 2 and altitudes of 50,000 ft.

The plane has a Pratt and Whitney J-75 powerplant, with 15,000 lb of thrust without afterburner.

Strike range can be extended by refueling from jet-augmented tankers.

NEW PLANT PRODUCES HIGH ENERGY FUELS

A high energy boron-based chemical fuel is being produced under an expanded Navy program at a new research and production center 17 miles north of Niagara Falls.

Called HEF-2 (High Energy Fuels 2), the fuel is made at a new $4,500,000 plant built and operated for the Navy by Olin Mathieson Chemical Corp. The program developed from Project ZIP, launched by the Navy's Bureau of Aeronautics in 1952 to prepare carboboranes.

Because boranes — compounds of hydrogen and boron —have heating values greater than 28,000 Btu's per lb, the high energy fuels may be used where range, speed or payload of aircraft and missiles have to be increased. HEF-2 reportedly continues to burn at higher altitudes than present jet fuels, which have heating values of about 18,600 Btu's.

A boron-base fuel called HEF-3 will be produced for the Air Force at a $45-million plant being constructed near the Navy facility.

SOLAR RECEIVES CONTRACT FOR LACROSSE NOSE CONE

Solar Aircraft Co. has received a contract for nose

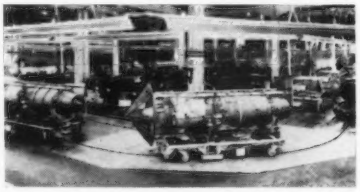
cones and fuselage support sections for the Lacrosse guided missile.

Besides the nose cone project, at the San Diego plant, Solar builds assemblies for Atlas, Titan, Polaris and Jupiter; precision lightweight fuselages for the Falcon; parts for the power plants of air-breathing missiles and engine components for the Snark, Regulus I and Matador.

ASSEMBLY LINE SETUP FOR JET ENGINE SERVICE

A new system of jet engine service and overhaul is designed to eliminate up to 50 per cent of material handling normally associated with jet engine disassembly and assembly.

Using conveyorized production line concepts, system



was perfected by the Automatic Warehousing Branch, Pesco Products Div., Borg-Warner Corp.

Basic tooling, accommodating all jet engine models, falls into six categories; basic assembly dolly, bulk parts and sub-assembly carriers, miscellaneous tooling and fixtures; engine test instrumentation equipment; turbine rotor assembly

and transportation dolly; engine assembly and transportation dolly.

System consists of parallel conveyorized assembly drag line and parts line, with assembly dolly and its related parts carriers traveling at the same speed.

STEPS TAKEN AGAINST AIR COLLISIONS

Civil Aeronautics Administration has ordered its 92 aircraft to be marked with daylight fluorescent paint for increased visibility in the air.

The markings will cover 15 to 20 per cent of the aircraft with "Blaze" orange paint bordered in black.

Painted surface includes wing tips, two wide stripes on upper and lower wing surfaces, tail assemblies, a stripe along the underside, and stripes along the sides. Aircraft not carrying airborne radar will also be painted on the nose.

Other safety developments include a new Atkins anticollision lighting system demonstrated by engineers of Minneapolis-Honeywell Regulator Co. A high intensity blue-white capacitance discharge light flashes a different sequence to front, side, and rear. Light can be seen in the day twice as far as plane itself.

CREDIT WHERE IT IS DUE

The editors of AMM regret the omission of Hugh H. Muller, Technical Assistant, Chem-Mill Div. of Turco Products, Inc., in the credit lines for "Chemical Milling" (May, 1958).

Chem-Mill Div. of Turco Products, Inc., was granted an exclusive license by North American Aviation, Inc., to grant sublicenses to other firms for the Chem-Mill process.

TALOS ARMS CRUISER

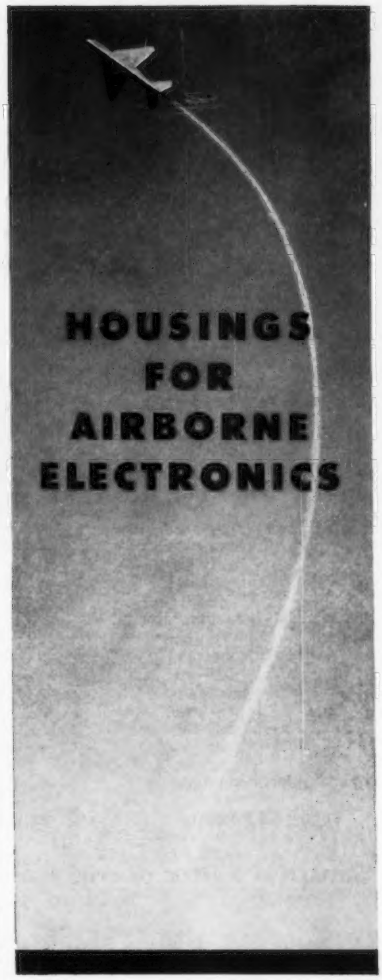
Business end of a Talos guided missile is shown aboard newly commissioned U. S. S. Galveston, first of several cruisers to be so armed. After being accelerated to supersonic speed by a solid-fuel rocket booster, Talos is propelled by a 40,000 hp ramjet engine. Built by Bendix Aviation Corp., at Mishawaka, Ind., under a $27-million contract, the weapon with its nuclear capability can destroy enemy aircraft and surface targets at ranges of over 65 miles.

VTOL COCKPIT DESIGNED FOR INSTRUMENT FLIGHT

A unique cockpit for VTOL (vertical takeoff and landing) aircraft has been developed by human dynamics engineers.

The cockpit includes vertical indicating instruments instead of dial types, a tiltable pilot's seat rotating through a 45-deg arc and adjusting to both horizontal and vertical attitudes, "side stick" control, and ultra-sensitive altitude and attitude indicating instruments.

Aimed at making possible all-weather instrument flight in jet aircraft, the cockpit was developed by Ryan Aeronautical Co., San Diego, Calif.



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Long a prime military contractor, Kaman is also a leading subcontractor to outstanding aircraft and missiles producers. Experience in processing and fabrication of magnesium and aluminum coupled with complete manufacturing and assembly facilities of over 500,000 square feet enable us to produce the most complicated housings and other assemblies for airborne electronic equipment to the most precise tolerances.

May we send you our 16 page illustrated brochure of equipment and facilities?

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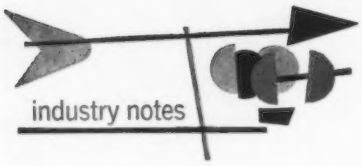

INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

VALUE OF NET SALES AND BACKLOG OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data are in Thousands of Dollars

NET SALES

Product and Type of Customer	Three Months 1958	Three Months 1957
Complete Aircraft and Parts		
For U. S. Military Customers	$1,410,000	$1,241,000
For Other Customers	297,000	261,000
Total—Aircraft and Parts	$1,707,000	$1,502,000
Aircraft Engines and Parts		
For U. S. Military Customers	$ 465,000	$ 501,000
For Other Customers	80,000	97,000
Total—Engines and Parts	$ 545,000	$ 598,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 40,000	$ 22,000
For Other Customers	10,000	12,000
Total—Propellers and Parts	$ 50,000	$ 34,000
Total—U. S. Military Customers	$1,915,000	$1,764,000
Total—Other Customers	$ 387,000	$ 370,000
Other Products and Services	$ 556,000	$ 536,000
Total—All Products	$2,858,000	$2,670,000

BACKLOG

Product and Type of Customer	March 31 1958	March 31 1957
Complete Aircraft and Parts		
For U. S. Military Customers	$ 6,470,000	$ 8,304,000
For Other Customers	2,672,000	2,974,000
Total—Aircraft and Parts	$ 9,142,000	$11,278,000
Aircraft Engines and Parts		
For U. S. Military Customers	$ 2,124,000	$ 3,346,000
For Other Customers	602,000	722,000
Total—Engines and Parts	$ 2,726,000	$ 4,068,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 95,000	$ 151,000
For Other Customers	27,000	43,000
Total—Propellers and Parts	$ 122,000	$ 194,000
Total—U. S. Military Customers	$ 8,689,000	$11,801,000
Total—Other Customers	$ 3,301,000	$ 3,739,000
Other Products and Services	$ 2,334,000	$ 2,255,000
Total—All Products	$14,324,000	$17,795,000

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units 1958	Units 1957	Value in Thousands 1958	Value in Thousands 1957
January	579	584	$ 62,311	$ 48,431
February	510	523	65,046	49,278
March	697	675	35,133	46,636
April	704	657	47,496	57,980
May		672		84,136
June		590		69,497
July		525		70,649
August		519		62,990
September		466		54,911
October		474		45,687
November		516		47,213
December		544		44,856
Total—Year		6,745		$682,264
Total—4 Mos.	2,490	2,439	$209,986	$202,325

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

Month	Thousands of lbs. 1958	Thousands of lbs. 1957	Avg./Aircraft 1958	Avg./Aircraft 1957
January	1,909.9	1,574.9	3,299	2,697
February	1,891.4	1,554.0	3,709	2,971
March	1,313.2	1,625.6	1,884	2,408
April	1,606.4	1,886.6	2,282	2,871
May		2,558.0		3,806
June		2,114.0		3,583
July		2,096.0		3,992
August		1,950.6		3,758
September		1,641.1		3,522
October		1,456.5		3,073
November		1,480.8		2,870
December		1,430.8		2,630
Total—Year		21,368.9		3,168
Total—4 Mos.	6,720.9	6,642.1	2,699	2,723

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1958	Units 1957	Value 1958	Value 1957
January	1,033	920	$ 8,883,000	$ 12,445,000
February	1,139	902	9,696,000	13,596,000
March	994	1,010	8,174,000	13,975,000
April	881	950	8,174,000	14,388,000
May		1,020		15,160,000
June		933		15,636,000
July		801		12,748,000
August		776		8,603,000
September		728		10,150,000
October		921		13,638,000
November		878		9,880,000
December		1,020		12,237,000
Total—Year		10,859		$152,456,000
Total—4 Mos.	4,047	3,782	$ 34,927,000	$ 54,404,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in Thousands) 1958	Total Hp. (in Thousands) 1957	Avg. Hp. per Engine 1958	Avg. Hp. per Engine 1957
January	459.9	604.4	445	657
February	518.2	647.0	455	717
March	440.7	679.2	443	672
April	428.0	668.2	486	703
May		715.8		702
June		730.4		783
July		590.4		737
August		425.6		548
September		482.8		663
October		628.3		661
November		473.0		539
December		586.2		575
Total—Year		7,231.3		666
Total—4 Mos.	1,846.8	2,598.8	456	687

ROCKET-POWERED GI'S MAY VAULT OBSTACLES

Research on small rockets enabling soldiers to jump like human grasshoppers includes a new jump belt under development at Reaction Motors Div. of Thiokol Chemical Corp.

The Reaction unit is strapped to the soldier's waist under his field pack. Small rocket nozzles are located at his hips. The propellant is contained in chambers on the ring at small of the back. The Rocket unit itself is lighter and smaller than conventional field packs.

Specific uses which have been described include attacking pillboxes by leaping over them and attacking from behind; jumping from landing boats, and through difficult terrain, being "shot" across rivers.

Illustration below shows Ed Kurczewski, test stand assistant for Reaction, demonstrating a power-assisted leap using an early version of the belt. The unit, which established proof of the jump belt principle, enabled him to "vault to extraordinary heights," according to company officials.

Army engineers look to the rockets in general as possibly the greatest tactical advantage ever introduced into warfare. Believed more efficient than helicopters harnessed to a soldier (another development project), the rockets in Army plans will transport men "almost instantaneously" over distances up to 100 yards at a maximum altitude of 20 ft.

continued on next page

3 ELEMENT
SPEED SENSITIVE
SWITCHES

DIMENSIONS . . . 2⅝" Dia. x 6" Long
WEIGHT . . . . . 1¾ lbs.

Synchro-Start Model GA-3 speed sensitive switches are suitable for installation on AND20005 aircraft tachometer drive pad.

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These units are adjustable while running, splash proof, and have a flexible drive shaft to compensate for mounting misalignment. They can be supplied to open or close 3 separate circuits at any speeds between 1,200 and 6,000 RPM in the standard governor. Special speeds either above or below the standard model must be referred to our Engineering Department.

Other governors with 1 and 2 switches are available with a variation of mountings for tachometer cable and SAE coupling drives.

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8151 NORTH RIDGEWAY AVENUE, SKOKIE, ILLINOIS
Manufacturers of
AUTOMATIC ENGINE CONTROLS • SPECIAL CONTROL PANELS
SAFETY ALARM SETS • D.C. SOLENOIDS • HEAVY DUTY RELAYS

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Circle 69 on Inquiry Card, page 65

MISSILES HANDLING BIG ITEM FOR DISCUSSION

Missiles received a large share of attention at the National Materials Handling Show in Cleveland.

Besides discussing equipment for moving missiles, the conference covered support equipment: buildings for personnel, stores, missiles and spares; construction and maintenance; camouflage; electrical equipment and power; fire-fighting equipment; liquid oxygen manufacturing; processing and packaging.

"Gobbled launching systems" were assailed by Michael L. Mastracci, American Machine and Foundry Co.

"Oftentimes the missile is completely developed before the handling contractor is brought in," claimed Mastracci. "Hence some of our gobbled launching and handling systems of today."

The conference learned that from 20 to 35 per cent of all missile money goes for mechanical ground gear.

Aspects discussed:

• Air compressors. These supply air at 80 cu. ft. per min., at 5000 psi. The compressors and all auxiliary equipment are usually in one van or "air-source trailer." The lox manufacturing plant is mounted on one trailer and requires a bulk lox transport tank truck and a large storage trailer for storing lox as it is manufactured. Electric power is produced on still another van. The fire truck is the standard type, and tows an extra supply of water. Additional mobile units include a truck-mounted crane with bulldozer attachment and personnel carriers for the crew.

• Air conditioning and humidity and temperature control. Air conditioning units handle from 9000 to 60,000 Btu, and heaters put out up to 60,000 Btu. Fortunately, liquid nitrogen is a by-product of the production of the liquid oxygen, and can be used for cooling the distillation process, or the cooling requirements would be even more severe.

• Protection of personnel, and the work area. This calls for a temporary, portable, "check-out" shelter where the crew can work until launching time.

• The "Factory-to-Launch" sequence. This includes shipment of components to contractors; missiles to arsenals, to launch sites. Here the missiles are handled for launching, components are cycled during testing and standby. Then defective missiles, components, etc., must be returned to the manufacturer for repair or maintenance.

"Most overlooked possibilities in missiles handling" was description of standard items such as the fork lift truck, overhead hoists, tramrail, etc., old standbys, which offer the plus-factor of the human "touch."

Too much specification of special containers, without consideration of actual needs for safe transportation was criticized. Considerable savings in time, weight and cost were made by the Navy, since they do not use containers on shipboard. For loading on board ship, transferring ship-to-ship, or protection on shore, they use the "grasshopper." This is an open-framework device which straddles the missile, picks it up and holds it snugly. Shock-absorbing legs prevent damage from vibration or jolting.

Handling systems for firing the missiles differ with each type. The "shotgun" type, such as Nike, Bomarc, etc., does not require great speeds. However, the "machine-gun type" such as the Hawk, Talos, and some of the Navy missiles, must be automatic and fast.

NEW NYLON FABRIC PROTECTS MISSILE-MEN

Protective clothing for personnel on missile launching pad sites is being made from a nylon fabric coated with the new fluorine-based "Viton" synthetic rubber.

A new member of the Du Pont family of "Fairprene" coated fabrics, material possesses resistance to heat, chemicals and fuels.

AGMA ELECTS BORISCH, GIVES AWARD TO DUDLEY

The American Gear Manufacturers Asso. elected E. F. Borisch as president at its 42nd annual meeting in Hot Springs, Va.

Besides Borisch, executive vice president of the Milwaukee Gear Co., the other officers elected were:

John L. Buehler, Indiana Gear Works, vice president, Gear Products Div.; Folke Richards, Westinghouse Electric Corp., vice president, Technical Div.; and J. F. Murray, Winsmith, Inc., treasurer.

The association's Edward P. Connell award went to Darle W. Dudley, of General Electric Co.'s Gear Engineering Div.

PROJECTS, PEEVES, PROPOSALS AIRED AT NATIONAL MISSILE INDUSTRY GATHERING

The missile industry took a long look at itself at its first national conference.

Some 500 industry leaders, meeting in Washington, heard that:

- A reconnaissance satellite as large as Sputnik III will be in orbit within 12 to 18 months.
- Sending a man into space, and returning him safely, is now a top priority item in the nation's spatial effort.
- The government will begin production of a million-lb-thrust space engine.
- Commercial applications of rocket propulsion may include giant rocket-glider airlines in ten years.
- Government is being waged to set up smoother contracting, research and development, and production systems.

Saying the U. S. has done a "magnificent" job of catching up to a five-year Russian headstart in the large rocket boosters, Dr. Herbert F. York, chief scientist of the Defense Department's Advanced Research Projects Agency, told the conference that an evaluation study has been completed on a million-pound-thrust rocket engine. He predicted production would begin "in less than a month or two." York put the U. S. position at about one year behind Russia in the large rocket field. "Within 12 to 18 months we will have satellites up of the same scope as Sputnik III," said the scientist, adding:

"We are now giving the most attention to a manned satellite. We are in the process of forming up which route this will take."

Dr. Walter R. Dornberger, technical asst. to the president of Bell Aircraft Co., charged that proposals dragged along because of cumbersome okaying procedures in the services. He urged a seven point priority list aiming at a realistic, bold, and organized approach to the coming space age.

The list:

1. Long - range ballistic missiles.
2. Research vehicles in "cis-lunar space" between earth and moon.
3. Manned or unmanned weapon systems in cis - lunar space, including hypersonic rocket gliders, reconnaissance satellites, communications satellites, ferry and supply rockets, space weapons.
4. Data - gathering research vehicles for trans-lunar space.
5. Space vehicles for commercial applications.
6. Prestige flights.
7. Spectacular flights.

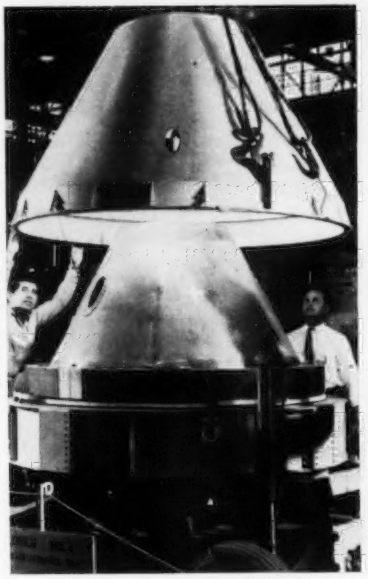
Dornberger, who as an army general in World War II headed the Reich's V-2 rocket program, said nuclear rockets and high energy propellant power plants should have top priority in order to put up heavy payloads. Calling for space power plants using the energy of the sun for fuel, he asked "much more effort" on solving how one space vehicle could meet another at a predetermined spot.

On commercial uses of rockets, Darrell C. Romick, head of the Astronautics Sections, Goodyear Aircraft Corp., said commercial aircraft shooting to outer space and gliding to a distant destination might be available in ten years. These might carry 80 people from San Francisco to Tokyo in 1½ hr.

New markets for metals, plastics and other materials were predicted because of commercial missile use for transportation and communication.

Industrialists predicted that small missiles will be used someday for weather research, cloud seeding, and perhaps even crop-dusting.

The conference heard proposals to revamp government contracting methods. Work groups which decide on contracts were called technically undermanned, and prone to fall for gilding on a bid.



NOSE CONE FOR ATLAS IS PACKED FOR TRAVEL

Nose cone for Atlas ICBM is packed into its carrier base by engineers at General Electric Co. Developed at the GE Missile and Ordnance Systems Dept., Phila., under a $158-million contract, nose has blunt front to produce the high drag-to-weight design used to combat re-entry heat.

The upper part of the carrier case is here being lowered over the afterbody which contains control and stabilization equipment keeping the cone in proper trajectory. Front of the cone remains in the lower part of the case until the cone is ultimately mated with the missile.

july 8-11
national summer meeting,
the institute of the
aeronautical sciences,
ambassador hotel, los angeles, calif.

◆

july 14-15
triennial inspection
national advisory committee for
aeronautics.
ames aeronautical laboratory,
moffett field, calif.

◆

july 24-25
fifth annual symposium on computers
and data processing
albany hotel, denver, colo.

◆

july 29- 31
third annual exhiborama.
second annual symposium.
society of photographic
instrumentation engineers, statler
hotel, los angeles

◆

august 6-8
technical conference on non-linear
magnetics and magnetic amplifiers,
american institute of electrical
engineers,
hotel statler, los angeles, calif.

◆

august 7-8
annual conference discusses quality
control at the modern pace,
western region, american society
for quality control,
el cortez hotel, san diego, calif.

◆

august 13-15
conference on electronic standards
and measurements,
national bureau of standards, american
institute of electrical engineers,
and institute of radio engineers,
bureau of standards laboratories,
boulder, colo.

◆

august 17-23
engineering seminar, missiles
operation research
pennsylvania state university,
university park, pa.

august 19-22
western electronic show & convention,
institute of radio engineers,
ambassador hotel, los angeles, calif.

◆

august 25-30
ninth annual congress,
international astronautical federation,
amsterdam, holland

◆

september 1-13
international conference on
peaceful uses of atomic energy,
united nations,
geneva, switzerland

◆

september 3-5
cryogenic engineering conference,
massachusetts institute of technology,
cambridge, mass.

◆

september 8-13
first international congress of the
aeronautical sciences,
palace hotel, madrid, spain

◆

september 15-19
instrument-automation conference
and exhibit (international),
instrument society of america,
convention hall, philadelphia, pa.

◆

september 22-24
seventh annual meeting,
standards engineers society,
benjamin franklin hotel,
philadelphia, pa.

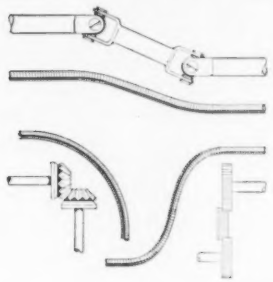
◆

september 22-24
1958 meeting
professional group of telemetry
and remote control,
bal harbor, miami beach, fla.

◆

september 29-october 3
semi-annual meeting and
western tool show,
american society of tool engineers,
shrine exposition hall,
los angeles, calif.

FLEXIBLE SHAFTING REDUCES GEARING



Flexible Shafting reduces the noisy and cumbrous gearing used in conjunction with solid shafts. It has the ability to transfer power from remote places, over, under, and around obstacles found in the path of installation between the drive and the driven units. Flexible Shafting requires very few parts, making them inexpensive; whereas solid shafts using universal joints, miter gears, and gear trains, many times would not be feasible because of their noisiness or lack of economy. With a Flexible Shaft assembly, design may be simplified and your engineering time spent on other necessary component parts without having to worry that they will create obstacles when placed where you want them.

Flexible Shafting cuts down on vibration thus offering long life with very little maintenance required. For complete Flexible Shaft information, write F. W. Stewart Corporation, 4311 Ravenswood Ave., Chicago 13, Illinois.

(Advertisement)

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- **NAVAHO**
- **FIREBEE**

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